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THE MYSTERIOUS BIRDS OF PATAGONIA.

By R. LYDEKKER, B.A.Cantab., F.R.S.

IF I were asked to name one country more than another where there is a probability that unknown types of the higher vertebrates await discovery by the explorer or the naturalist, I should at once indicate the wilds of the interior of Patagonia. Still inhabited by wild and blood-thirsty Indians, and possessing a winter climate of especial severity, many of these districts are practically unknown to Europeans, while to the naturalist they are a veritable *terra incognita*. As a result of this freedom from European intrusion, the rhea, or South American ostrich, together with the vicuna, the Patagonian cavy, and the pampas-deer, all of which are on the verge of extermination from the pampas of the Argentine, still flourish in large numbers on the plains and mountains of Patagonia. Even this remote country is, however, slowly yielding to the advance of civilization, and large areas in the Chubut district and on the Rio Negro are already in the hands of the sheep-farmer; so that ere long we may expect the same destruction to overtake the native animal life which has already befallen that of the Argentine pampas. It, therefore, behoves the naturalist to use every effort to secure specimens of such animals as may prove to be new before they are swept away by the relentless hand of man.

That there may be new species of opossums, if not of other kinds of marsupials, as well as rodents, in Patagonia is, I think, highly probable; but what I wish to lay before my readers in the present communication is the evidence in favour of the existence in the interior of the country of a small bird more or less closely allied to the rheas, or South American ostriches, which are exclusively characteristic of the continent from which they take their name. Up to the present, European naturalists have had no suspicion of the existence of the bird in question; and since the ostriches and their allies form a group of especial interest both to the anatomist and to the student of the geographical distribution of animals, the discovery of a new species, if not a new genus, would be one of the most important events in the history of modern ornithology. I say *would be* with a purpose, because, unfortunately, we have no actual specimen of this presumed new bird, which is at present only known to us tangibly by a single egg.

Before proceeding further, it is advisable to make brief mention of the known existing representatives of the ostrich-like birds, all of which are characterized by the want of the power of flight, and the absence of a keel on the front of the breast-bone. From the latter feature, the group to which they belong is scientifically known as the *Ratitæ* (from *ratis*, a flat-bottomed boat), in contradistinction to the *Carinatæ* (*carina*, a keel), which include the whole of the remaining birds of the present day. Commencing with the Australian and New Zealand representatives of the group, we have first of all the diminutive kiwis (*Apteryx*) of the latter country, distinguished from all their kindred not only by their small dimensions, but likewise by their elongated and slender bill, adapted for probing in soft ground for insect-food. As a physiological peculiarity of the kiwis may be mentioned the enormous relative size of their eggs, which appear nearly half as large as the bodies of the birds by whom they are laid.

Another group is formed by the cassowaries (*Casuarius*) and emeus (*Dromæus*), the former of which range over the Papuan islands and the northern part of Australia, while the latter are exclusively Australian. Both these kinds of birds are characterized by the feathers (which are more or less hair-like in structure) being apparently double, owing to the circumstance that the secondary or after-shaft of each is as large as the main shaft. They also possess the common feature of laying eggs of a dark green colour, with the surface of the shell peculiarly roughened. The cassowaries, of which there are nine or ten species, differ from the two kinds of emeu by the horny helmet crowning the head, by the great elongation of the innermost of the three toes, and by some portion of the neck being bare, and generally ornamented by pendant fleshy wattles.

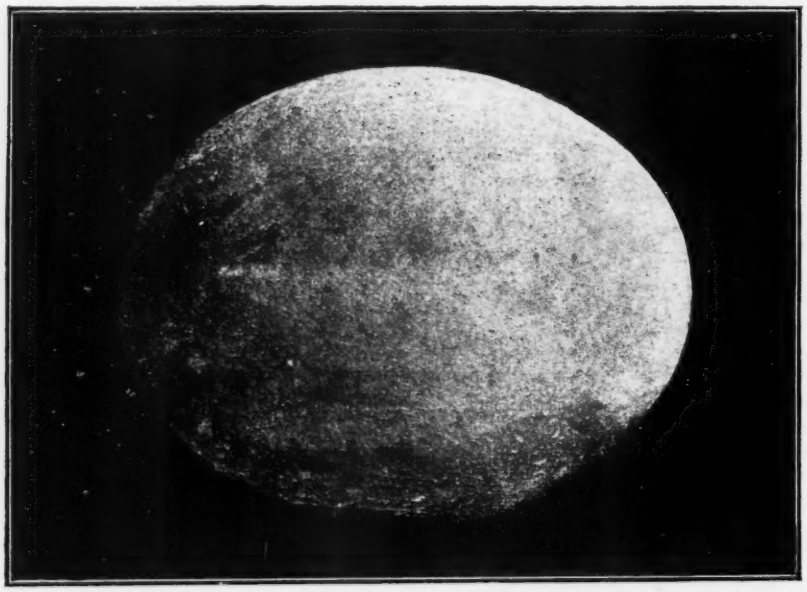
As the emeus and cassowaries form one well-marked group of the ratite birds, so the ostrich and the rheas constitute a second section; the latter section being distinguished by the normal structure of the feathers, and the light colour and smooth surface of the shell of the egg. Towering high above his kindred, the African ostrich (*Struthio*) not only exceeds all other existing birds in height, but differs from the whole of the other members of the avian class, both recent and extinct, in the reduction of the number of toes on each foot to two. Now although English residents in South America, with that pertinacity for applying Old World names to New World animals for which they are so distinguished, will insist on calling rheas ostriches, the circumstance that they have three instead of two toes clearly shows that they have no right to that title. Rheas are represented by three species, namely the common rhea (*Rhea americana*), of which the eggs are

pale straw-yellow when first laid; the long-beaked rhea *(R. macrorhyncha)*, which is perhaps only a variety of the latter; and Darwin's rhea *(R. darwini)*, distinguished by laying eggs of a very pale sea-green colour. Occasionally wholly white rheas are met with, but these are probably only albino individuals of the ordinary species. A strikingly handsome bird in its plumage of black and grey, the male rhea stands about four feet in height. The egg is a nearly symmetrical oval, with the ends usually pointed, and the longer diameter about six and a quarter, and the shorter three and three-quarter inches, the shell being marked by a number of small punctures. Occasionally, however, specimens are met with in which the form is more rounded.

From the foregoing observations it will be seen that the ratite birds of the present day, hitherto described, are included in only five genera, and that, with the exception of Australia, no country is the home of more than a single genus; while all, save the kiwis, are birds of large size.

Turning now to the evidence in favour of the existence of a hitherto unknown diminutive representative of the group in Patagonia, it may be mentioned in the first place that the whole of the information in regard to it has been supplied to me by Dr. H. P. Moreno, the learned director of the museum at La Plata, to whom I am indebted for the photograph of the egg herewith given. That gentleman tells me that, when exploring some years ago in the interior of Patagonia, he saw numbers of small flightless birds which he at first took to be young rheas. Struck, however, by seeing numerous parties of these birds, as well as by the absence among them of any of the ordinary rheas which might be their parents, he was soon led to discard this view. On asking the Indians by whom he was accompanied whether they knew the birds, Dr. Moreno was informed that they were perfectly familiar with them, and knew them to be a small kind of rhea. Being unfortunately unable to obtain specimens, Dr. Moreno on his return asked a friend, who had travelled in the same district, whether he had any knowledge of the birds. The reply was that, not only did he know them well and had often seen them, but that he actually had in his possession an egg which he had picked up. Naturally anxious to obtain such a treasure, Dr. Moreno asked if his friend would present the egg to the museum—a request which was promptly and graciously granted. From that time (some ten years ago) till the present day, that priceless and unique specimen has lain undescribed in the La Plata Museum, and the readers of Knowledge have consequently the pleasure of being the first to see a published figure. I am glad to be able to add that a beautiful wax-model has been prepared for me, which will, in due course, be handed over to the Natural History Museum.

The specimen is entire, that is to say the contents have been dried up by exposure, and now form a hard substance which rattles when the shell is shaken. In form it is a short oval, with blunt ends, the longer diameter being three and a half, and the shorter nearly two and three-quarter inches. As shown in the photograph, the shell is marked by a number of small punctures, as in the egg of the common rhea; and the original colour was probably yellowish-white, although the shell is now stained dark in several places from contact with the soil. The shell is very strong and thick, and the egg bears all the indications of having been laid by an adult bird; while its perfect symmetry indicates that it is not an abnormally small egg of an ordinary rhea.



Egg of the Dwarf Rhea. From the only known specimen, preserved in the Museum at La Plata. Natural size.

That the specimen is not the egg of any known South American bird may (on the assumption that it is a normal and full-sized example) be regarded as certain; while all its characters point to its being the egg of a ratite bird. This being so, and taking into account the statement of two independent European witnesses as to their having seen small rhea-like birds, which were perfectly well known to the Indians as adults, the presumption of the existence in Patagonia of a ratite of the approximate dimensions of a kiwi becomes so strong as to amount almost to a certainty. A further presumption is that this unknown bird is allied more or less closely to the rheas, but whether it belongs to the same genus cannot be ascertained until the acquisition of actual specimens. In the meantime I think we may provisionally call this unknown bird the dwarf rhea, or, scientifically, *Rhea nana*, although it is quite possible that it may represent a genus by itself.

This is at present all the available information concerning the mysterious bird of Patagonia, and one of my objects in noticing the unique egg in a popular publication like Knowledge is the hope that all my readers who have friends or relations in Patagonia may do all in their power to stimulate them to use every effort to obtain a specimen of the creature itself. If this should ever be accomplished, what is now to a great extent hypothesis would be converted into a certainty, and zoological science would be enriched by a most important addition.

THE RISE OF ORGANIC CHEMISTRY.

By VAUGHAN CORNISH, M.Sc., F.C.S.

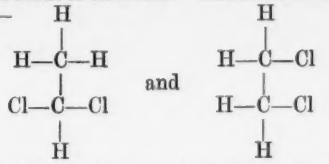
ORGANIC chemistry, the study of the hydro-carbons and their derivatives, is a science of the present century. Some of the technical processes connected with the preparation of organic substances are, however, of very ancient origin—brewing, for instance, and the art of soap-making. It is the scientific aspect of the subject with which we are concerned in the present article, and which occupies the greater part of Prof. Smithells' new and enlarged edition of Schorlemmer's "Rise and Development of Organic Chemistry."

Lavoisier showed that the decomposition of sugar by fermentation proceeds according to the conditions of the law of conservation of mass, the carbonic acid and alcohol produced being equal in weight to the sugar from which they are formed. Early in the present century the Swedish chemist, Berzelius, showed that the composition of organic substances conforms to the laws of constant proportions and of multiple proportions, which Dalton and others had shown to be characteristic of mineral compounds. The way was now paved for the recognition of the study of organic materials as a part of the domain of chemistry conforming to the same laws as those which govern the chemical properties of mineral substances. Research in the organic branch of chemistry was immensely facilitated by Liebig's work in perfecting the principal process of organic analysis, the well-known "combustion" which is still the *pons asinorum* of the student's laboratory course. From Liebig's time the progress of organic chemistry has been marvellously rapid. The compounds of carbon are, for the most part, so "reactive" that the labour of the investigator is quickly rewarded by the production of some novel substance—often useful or curious—the discovery of which leads in its turn to the production of other bodies related to, but differing from it. The binding element in the majority of these is carbon. The carbon atoms seem to have an almost unlimited capacity for catching hold of and hanging on to one another, and at the same time they retain their hold upon one or more atoms of other elements with which they have been associated. Thus, in the laboratory of the plant or animal body, and in the laboratory of the chemist, are built up compounds of almost infinite complexity, though containing for the most part but few of the chemical elements. Carbon is present in all, hydrogen in almost all, and oxygen in a majority of cases. Nitrogen occurs frequently, and the other elements in smaller quantity and comparatively seldom. The known hydro-carbons—*i.e.*, compounds containing only hydrogen and carbon—number four hundred, whilst few of the elements except carbon combine in more than two or three proportions with hydrogen.

The total number of carbon compounds is said greatly to exceed that of all the other known chemical substances. Among the organic bodies which have been produced in the laboratory are many useful drugs and invaluable anæsthetics; dyes, of which many are brilliant and some are beautiful; and powerful explosives, the discovery of which has probably proved beneficial to manufacturers of war material. But in the limits of this article we must not diverge from science to technology.

The facility with which chemists can transmute one carbon compound into another has led to great developments in our knowledge of the mechanism of chemical reactions, and of the chemical structure of substances. Chemical formulæ, from expressing merely the quantitative composition of compounds, were soon used to express the methods of formation and decomposition of organic substances. As knowledge advanced it was seen that the formulæ could be made to indicate the way in which the atoms were united one to another. It appeared from the study of organic chemistry that the attraction or union of an atom is not so much with all the rest of the molecule as with some neighbouring atom with which it is closely united or related. The *graphic formulæ*, with which modern chemical books are full, express, symbolically, the order or arrangement in which the atoms of the compound molecule are bound or linked together. To such perfection has the symbolical expression of the constitution of organic substances been brought, that the manipulation of these symbols often furnishes a valuable guide in the prosecution of new researches. No mode of expressing graphically *on paper* the composition of a molecule can, however, be expected to be quite satisfactory if it fails to take account of the fact that the atoms of a molecule are not all distributed, and do not all move, in one plane. The ordinary graphic formula of the text-book has the same faults as, say, the Bayeux tapestry, or a Chinese battle picture—it takes no account of perspective. The more recent use of *glyptic* symbols (which look like outlined figures of crystal form), or of actual models, is an important extension of this domain of scientific symbolism.

We must explain shortly how these developments have come about. The study of carbon compounds led to the discovery of *isomeric* bodies which differ in their properties, although their analytical composition is identical. These differences must, it seems, be explained on the supposition of a different grouping of the chemical atoms, and the phenomena of isomerism are to be classed along with those of allotropy, which are exhibited by several elementary substances, notably by carbon itself (*vide* KNOWLEDGE, 1892, "Carbon"). In the case of carbon compounds, it was found possible in many cases to express these differences by the graphic formulæ referred to above. Thus, there are two substances of very different properties, the percentage composition of which is expressed by the formula $C_2H_3Cl_3$—the symbols C, H, and Cl standing for weights of carbon, hydrogen, and chlorine, proportional to the weights of the atoms of these bodies. It was found that in one of the two substances whose composition is expressed as above, both chlorine atoms were bound up to the same carbon atom, whereas in the other the reactions showed that each carbon atom was in intimate connection with only one atom of chlorine. These facts are symbolized as follows:—



But these graphic symbols are insufficient to explain some cases of isomerism. For such cases it is useful, instead of using the symbol —C—, to represent the carbon atom by a tetrahedron.

This symbol expresses the essential fact that the carbon atom has a fourfold power of union with other atoms, and we symbolically express the union by attachment to the *corners* of the figure. It is generally sufficient for the purpose in view if one or two carbon atoms are thus fully represented, the ordinary symbol being employed to show the functions of the other carbon atoms. The two substances, fumaric acid and maleic acid, have the molecular

composition $C_4H_4O_4$, and the study of their reactions shows that each has two groups CO_2H, in which the hydrogen is bound to carbon only through the connecting link of the oxygen atom, whereas the remaining two hydrogen atoms are united directly to carbon. Two graphic representations may be made, which in a condensed form appear thus—

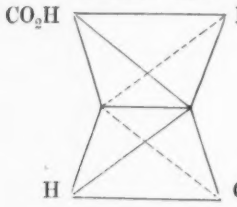
$$CO_2H \,.\, CH \,.\, CH \,.\, CO_2H$$

and

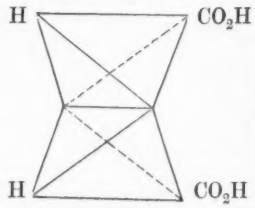
$$CH_2 \,.\, C \begin{cases} CO_2H \\ CO_2H \end{cases}$$

The latter symbol would indicate that *two* CO_2H groups are united to one carbon atom. The reactions of the substance so represented are, however, altogether against this supposition, and the graphic representation therefore fails. If, however, we represent the functions of two of the carbon atoms more fully by symbolizing these atoms as tetrahedra, we can represent very well the observed differences in the two acids, by taking account of the arrangement in the solid instead of regarding the apparent arrangement on the flat. In the symbols given below, the dotted lines of the tetrahedra indicate those edges which would be invisible if we were dealing with a wooden model, or with an opaque crystal of the same form.

Fumaric Acid.



Maleic Acid.



A class of bodies which it is difficult to represent by any symbol are those known as *tautomeric*, in which one or more atoms appear to be in a state of alternating allegiance towards their more powerful neighbours. The hydrogen atom, which is the lightest and probably the fastest mover in the dance of atomic vibration, seems in some cases to have certain peculiar privileges of motion within the molecule, so that at successive moments it may be joined up to different atoms.

In the work of synthesizing or building up compounds which occur in Nature, the organic chemists soon outstripped their "inorganic" brethren. Lately, however, the French representatives of inorganic chemistry have again recovered the lead, and the diamond has been made, while starch and the albuminoids are still beyond the creative powers of the chemist. The early feats of organic synthesis were hailed as a triumph over the old belief in a mysterious *vital force*. All substances produced in the life-processes of animals and plants were supposed to owe their existence to the mysterious agencies of life, and to be inimitable by the chemic art. The synthesis of a host of such substances in the laboratory has shown that the mysterious powers of vitality were prematurely invoked, and that failure was pre-supposed when no true trial had been made. The case is somewhat analogous to the mistaken appeal to almost infinite periods of time as the condition of formation of the native crystals of ruby and diamond. In spite of all their past achievements, scientific men are ready enough, like other mortals, to cry out that their go-cart cannot get any further without the aid of some Herculean agency beyond their reach. As a matter of fact, however, the achievements of organic synthesis have only pushed the *vital force* theory a small distance further back, for none of the reproduced alkaloids, sugars, dyes, etc., are *organized* bodies, or show any sign or symptom of the germ of living power. Recent researches upon the molecular weights of organic substances (chiefly by Raoult's method, which is based upon the lowering of the freezing-point of solvents) appear to show that the simplest among the substances which are intimately associated with vital processes are of vastly higher molecular weight, and presumably vastly more complicated than any of the substances that have yet been synthesized. The great differences in the size of molecules is perhaps indicated by the phenomena of dialysis, so much used in physiological work for the separation of substances. Crystalloids, sugar for instance, will in solution pass through the pores of an animal membrane such as parchment, whereas *colloid* substances will not. It seems likely that in such substances, perhaps through the action of atoms such as those of carbon which have a power of multiplex combination, molecules or groups of atoms may "combine to net-like or sponge-like masses. . . . . We may perhaps further suppose that through the constant change of position of polyvalent atoms, these mass-molecules will show a constant change in the connected individuals, so that the whole . . . . is in a sort of living state.*

The idea thus brought forward may perhaps be expressed by saying that if ever chemists should succeed in obtaining albuminous bodies artificially, it will be in the state of living protoplasm." ("Rise and Development of Organic Chemistry," p. 261.) Now that an independent cell-life in the organism has been recognized, the distance seems but small which separates the organic chemist from the point where he may be expected to make his first serious attempt to ascertain if living matter can be produced otherwise than by the agency of living matter itself. Not every scientific man would be able to approach this world-old question without a preconceived opinion as to the ultimate answer which Nature has in store. Whatever be the answer which Nature has in store for us, it will be a duty to science to work at the problem until it is either solved in the affirmative or, like the transmutation of metals, found by experience to be beyond our power. Hitherto chemistry has not been in a position to attack the problem. The synthesis of organic compounds must be carried still further before science will have a bridge long enough to span the wide and formidable gap which divides our knowledge of the inanimate from that of the living world.

THE GLOW-WORM.

By E. A. Butler, B.A., B.Sc.

THE townsman seldom has the opportunity, often enjoyed by those who live in country districts, especially in the southern parts of England, of seeing what cannot fail to be regarded as one of the most remarkable sights in Nature, a living animal glowing with light as if it were on fire. The production of light is so frequently a consequence of the phenomenon of combustion, that it is difficult to dissociate them in the mind, and to imagine the former without being impelled to think of the latter, or at least to imagine a considerably elevated temperature. The production of brilliant light without any sensible increase of heat is so unusual a circumstance that it is puzzling to understand how it can take place, and still more, how it can be

* "In crystals and in dead bodies generally, matter is in static equilibrium . . . . in living organisms the equilibrium is dynamic." (*Nature*, Nov., 1894.)

associated with a living animal frame. The glow-worm is by far the most important terrestrial animal in Great Britain that manifests this phenomenon of "phosphorescence," though amongst marine animals, and amongst terrestrial species belonging to warmer latitudes, the phenomenon is of very much wider occurrence. In fact, there are few classes of animals that do not contain species which are, at some season or other, more or less phosphorescent; fishes, insects, myriapods, crustacea, mollusca, sea-squirts, worms, cœlenterates, starfishes, infusoria, all include phosphorescent species. In fact, so common is the phenomenon amongst marine organisms, that apparently we have in it the chief source of light to those creatures that live in the abysmal depths of the ocean, where the light of the sun never penetrates. But while the sea teems with glowing animals, they are not nearly so numerous on land, and, as already mentioned, the glow-worm is, in this country, practically the only terrestrial phosphorescent species which is likely to attract general attention, the few centipedes, worms, &c., that are its only rivals, being far inferior to it in brilliancy.

But it is not only as a phosphorescent being that the glow-worm is remarkable. In a great variety of respects it is abnormal, and these peculiarities we will now proceed to recount. It may be a surprise to some of our readers to be told that the glow-worm is a beetle, *i.e.*, a member of the order Coleoptera, to which also belong the blister beetle, the bloody-nose beetle, the bombardier beetle, and others that we have recently described. It is most nearly related to that section of the order which includes the well-known "soldiers and sailors," the reddish and bluish-black, soft-bodied flying insects that are so common in summer, not only in the woods and fields, but in the streets of our towns as well. Usually it is not reckoned as belonging to the same family as these creatures, but is placed in a different one next to them. This family is called *Lampyridæ*, and the English glow-worm is known as *Lampyris noctiluca*. It is the only species of its genus with which we are favoured in Great Britain, and in fact almost the only representative of the whole family, for only one other species, belonging to a different genus, is known as British, and that is a rare one, having been found only in two localities, and in both cases in towns; so that, for all practical purposes, the glow-worm may be taken as our one British representative of the family *Lampyridæ*. The family, in fact, is characteristic of tropical rather than of temperate latitudes.

The family *Lampyridæ* is one of eight, which are distinguished by their soft and flexible skin, very different from what is found in the majority of the beetle order, which includes the hardest-skinned of all insects. This soft-skinned section is called Malacodermata, in consequence of this peculiarity. It is curious that these malacoderms, notwithstanding their soft and yielding skin, are yet fiercely carnivorous. It is pretty easy to recognize a beetle of this section by its very soft body, which often has fleshy protuberances at the side, and its flexible wing-covers, which are more or less delicately hairy, and sometimes become slightly distorted by bending and shrivelling when the insect is dead. Some of the species are exceedingly beautiful, being bright scarlet, or brilliant metallic green, or exhibiting combinations of the two. The glow-worm has no such brilliancy of natural colour to recommend it, but makes up for this deficiency by the soft beauty of the greenish glow that appears in its abdomen in the dark.

The sexes of the glow-worm are so different that it will be necessary to describe each separately, and we will take the female first, as it is the more familiar. The appearance of the female glow-worm is so different from that of adult insects generally, that it is difficult to believe in its maturity, and still more in its being a beetle; in fact, its coleopterous nature would not easily be demonstrable were it not for the appearance of the male. The female (Fig. 1) is an absolutely wingless, grub-like creature, with a small head, which is completely concealed beneath a semicircular projecting scale, representing the dorsal part of the prothorax of an ordinary insect. Behind this scale are ten segments, all except the first and last similar in form, and each broadest behind, so that the edges of the body become saw-like, with ten notches. The first of the ten segments, representing the mesothorax, is more rounded than succeeding ones, and the terminal one, like the prothorax, is semicircular. The colour is blackish-brown above, with the margins of all the segments, and some patches in the outer angles of the first two, more or less yellowish or reddish. The whole surface is rough, and covered with extremely short silky hairs. Above, the insect is flat, the dorsal layer of each segment forming a sort of shield projecting at the sides beyond the parts beneath, though not to so great an extent as the semicircular shield which covers the fore part. Each of these trapezoidal shields has a slight ridge down the middle. The under surface is very different, being convex and paler in colour; the last three segments are almost white, and it is in these that the glow appears. Three pairs of short legs are carried by the three thoracic segments, and the head bears the usual pair of compound eyes, which are of moderate size, and a pair of short antennæ. As the insect walks, its abdomen trails along the ground, the legs being too far forward and too short to enable it to be raised. It will thus be seen that the insect looks very much like a larva, the thoracic shield being the only characteristic that conveys any other suggestion to a cursory glance.

Fig. 1. — Female Glow-worm, magnified two diameters.

The female is the only member of the family to which the name of glow-worm would popularly be applied. It is usually to be met with in the summer months on grassy or mossy banks, where it lies awaiting the advent of its mate, and showing at night, on its under side, a greenish glow which proceeds from two bright spots on the last segment, and from the greater part of the two preceding ones. Of course, therefore, the full brilliance of the light can only be seen when the insect is lying on its back. When disturbed it feigns death, curving its abdomen downwards, and bending up its legs. When left to itself, it is not, as can readily be imagined, a very active creature, and will often remain in the same spot for hours, or it may be days, together. In the daylight, owing to the absence of the luminosity, it is seldom noticed except by those who are familar with its form. In country roads it is sometimes to be met with crawling along near the foot of the hedge, or crossing from one side of the road to the other, and it may also be found underneath stones.

The appearance of the male (Fig. 2) is entirely different, and it is rarely discovered in a similar way to its partner. As it has the ordinary wings and wing-covers of a beetle, there is no difficulty in recognizing it as such. But, at first sight, it would not readily be connected with its mate, because the body, wherein lies the chief resemblance, is concealed by the closed wings; but if the elytra and wings are removed, the close resemblance between the two insects is at once obvious. There is the same semicircular shield in front, the same segmented and notched body, with

the same distribution of colour, and the same short legs and antennæ. It is the wings and elytra that make the male look so different. The elytra, or wing-covers, are long, narrow and parallel-sided, entirely concealing the body, and indeed projecting beyond it both at the sides and behind. They are of a greyish-brown colour, covered all over with minute pit-like depressions, and bounded by a raised rim all round; there are also two or three slightly raised parallel ridges on their surface, and the same clothing of minute and scarcely visible silky hairs covers them as is to be found over the rest of the insect. If we raise these wing-covers, we see a pair of smoky wings beneath them about twice as broad as the elytra, and slightly longer, so that they overlap one another when closed, and have to be slightly folded at the tip to get them beneath their covers. The nervures stand out distinctly as dark smoky lines, and at the extreme tip of the wing they meet to form a polygonal area which is destitute of nervures, so as to facilitate the slight folding that has to take place. The insect is a good flier, spreading its elytra, but using only its membranous wings for the purpose of flight. If placed on its back, it is said to right itself by slightly opening its wing-covers and thus getting its wings free, and so struggling over by their means. It is nocturnal in habits, and is therefore not often seen unless attracted by light. In places where they are common, an open window with a strong light burning inside will prove an irresistible attraction, and they may be easily caught as they fly towards the lamp.

Fig. 2.—Male Glow-worm, magnified two diameters.

In all the characteristics we have already described, the male, though so unlike his consort, in no respect differs from the ordinary beetle type. The only point which is at all exceptional is the large size and projecting form of the thoracic shield, but even in this respect the insect is not quite singular; other Coleoptera, such as the tortoise-beetles, show exactly the same arrangement. But there is a far more peculiar feature yet to be noticed, and that is the enormous size of the eyes. Of course, these cannot be seen from above, but if the insect be laid on its back, two large, round, black knobs will be seen almost touching one another, just in front of the first pair of legs and, therefore, under the thoracic shield. (Fig. 3.) A lens shows that they are covered with an immense number of hexagonal facets, and they are thus seen to be the compound eyes. They occupy almost the whole of the head, the mouth organs and antennæ being squeezed into a very small compass between them in front. As the insect lies in this position, another peculiarity is easily observable. A horny flap from the disc-like thoracic shield bends down on each side of the head, to which it fits so closely that the idea is irresistibly suggested of a broad-brimmed hat placed on the back of the crown and tied beneath the neck by a very wide ribbon. A similar arrangement is made in the female, but as the eyes are not nearly so large, the effect is not so striking.

Fig. 3.—Head of Male Glow-worm, from beneath.

Luminosity is not the heritage of the female only; the male possesses the power to a slight extent, though his brilliancy is far inferior to that of his mate, and is chiefly confined to the two bright points on the last abdominal segment. Hence the pale area of the abdomen is not nearly so extensive in the male as in the female, and an inspection of the dead insect even would be sufficient to lead to the conclusion of its far inferior brilliancy. In neither sex is the luminosity an external feature. The seat of the activity which gives rise to the light is internal, and the light merely shines through the transparent skin beneath. The light-producing organs are situated in the last three segments of the body, and consist of two layers of yellowish-white, rounded cells, abundantly supplied with a network of air-tubes from the spiracles. The two layers of cells, though similar in form, appear to differ in constitution and in function, those of one layer only becoming luminous.

It cannot be said that anything very satisfactory has yet been determined with regard to the real cause or nature of the luminosity. According to some careful investigators, it results from a process of oxidation of some of the contents of the luminous cells, produced in them as the result of nervous stimulus. The oxygen required for this purpose, it is maintained, is supplied from the outer air, which, introduced at the very conspicuous spiracles placed at intervals along the sides, finds its way to the light organs through the air-tubes. Thus the intensity of the light depends upon the vigour of respiration, supplemented by nervous activity. It is, however, difficult to understand how so bright a light should be produced in this way without any appreciable rise in temperature. The light appears to be, to some extent, under the insect's control, and the advocates of the oxidation theory contend that the regular intermittence of light which is observable in some species is produced by an alternate opening and closing of the spiracles, or at least synchronizes with acts of inspiration and expiration. Other observers, again, while maintaining the oxidation theory, deny that nervous stimulus has any connection with it, and still others deny the oxidation theory altogether.

It is not difficult to determine one function of the light. When one considers the apterous condition, the brilliant light, and the ordinary eyes of the female glow-worm, and contrasts with these the winged condition, the feeble light and the enormous eyes of her partner, it is evident that these are complementary features in the two sexes, and there can be little doubt, therefore, that one function of the luminosity is to serve as a sexual attraction, and guide the roving male to his destined spouse. But there is no reason why it should not have other functions as well, and that such is the case would seem to be implied in the fact that the insect is luminous in all its stages, and therefore long before it is sexually mature. The suggestion has been made that the light is protective in function, being a sort of warning signal, like the brilliant colours of certain caterpillars. Considering the softness of the female's skin, and its sluggish habits, it would seem to need more protection than usual, and the suggested use of the luminosity is therefore, at the least, plausible. It is not unreasonable to suppose that a would-be captor would think twice before seizing on so dangerous-looking a morsel. On the other hand, the insect is carnivorous, and furnished with a tolerably effective pair of jaws, so that it may perhaps be able to give a better account of itself in a struggle than its soft skin would lead one to suppose.

In confirmation of the sexual function ascribed to the luminosity, the Rev. H. S. Gorham has pointed out that in the family *Lampyridæ* the eyes are developed in magni-

tude in proportion to the light displayed; those species that show but a feeble light have but small eyes, and *vice versa*. The antennæ also are developed in inverse ratio to the light, and it is well known that a great development of antennæ often exists in those insects that can perceive their mates at great distances; thus, when one power of discovery is lessened, another is increased to supply the deficiency. Thus the species may be divided into three groups: first, those with plumose antennæ and small eyes, and with light appearing in small spots only; secondly, those with simple antennæ, larger eyes, and a considerable amount of light, both sexes being winged; and thirdly, those with quite rudimentary antennæ, extraordinarily large eyes in the male, and most brilliant light, accompanied by an apterous condition in the female, or, at most, with rudimentary wings in that sex. Evidently, therefore, the light-giving power, eyes, antennæ, and wings, are all related in the progress of their development, and it can scarcely be questioned that such a relation indicates a causal connection.

We may now sketch the life-history of this curious insect. Shortly after pairing, the female deposits her eggs. They are of large size and pale in colour, and are either placed in the earth or on moss or grass or other low plants, adhering to the spot on which they are placed by means of the viscid liquid with which they are wet. Curiously enough, the eggs are luminous as well as the insect that produced them. It might be thought that, considering where they have come from, this is not to be wondered at, since the appearance might be due to the moisture that covers their surface. But this is not the case, for if washed in pure water and then dried they still remain luminous. According to Dubois, they may be kept in water for an hour without losing their luminosity, though after the lapse of that time the light begins to wane; but if they are taken out when this occurs, they soon recover their brilliancy. Alcohol rapidly suppresses the luminosity, and boiling water destroys it immediately. The luminosity belongs to the contents of the egg, and not to the shell, so that the light shines through the transparent egg-shell. When the egg is hatched, such luminosity as there is appears in the larva, but the empty egg-shell loses every trace of it. Now, since this luminosity appears even in the youngest eggs, before the segmentation of the yolk sets in, it is evident that it is not, in this instance, whatever may be the case with the adult insect, dependent upon nerves or air-tubes, or indeed any anatomical element whatever, though, of course, oxygen can pass through the thin egg-shell without any special means of conveyance. The luminosity of the eggs is, however, greatly dependent upon moisture, and gradually disappears as the moss amongst which they may be lying dries up; it can be restored again, if not too far gone, by the application of moisture.

The larva is extremely like the perfect female, the most noticeable difference being the smaller size of the head shield. It may be found, of various sizes and ages, during the winter and spring, and becomes full-grown about April. The small size of the young larvæ will serve at once to mark their immaturity, since, of course, the adult insect does not grow; but the full-grown larva is less easy to distinguish from the adult female. Besides the shape of the fore parts, there are also minute differences in the feet and antennæ, which aid in their separation. Like the perfect insect, the larva is carnivorous, feeding upon snails, especially those of the genus *Zonites* or *Helicella*, small, flat, shining kinds, often seen under stones, moss, &c., and in damp places generally. At the end of the body it has some seven or eight short white rods, which are usually kept retracted within the body, but can be protruded at will, and these it is said to use for cleansing the fore parts of its body, should any of the snail's slime adhere to it during the course of a meal. The coloration of the larva is a little more distinct and variegated than that of the adult female; the centre part of the back is darker, and each segment has a reddish-yellow patch at its exterior angle.

As the insect in its larval stage is so much like the fully-developed female, we need not be surprised to learn that the pupa stage is a very short one. Very little metamorphosis, whether internal or external, has to take place, and a very brief time is quite sufficient for this. In little more than a fortnight after the larva has ceased to feed, the perfect insect appears, and the pupa stage itself does not occupy much more than half of this time. The pupa of the female does not differ much in appearance from either the larva or the adult; it remains in a curved position, with legs bent up, very much as the larva or perfect insect would do if feigning death. In the male pupa a difference can be seen; the wings begin to appear, but, of course, as usual, they are of very small size. When the insect is ready to escape from its pupa-skin, the latter slits in front, and the beetle wriggles its way out, a soft and nerveless thing. But its skin soon gains strength and consistency, and then it is prepared to atone for its fortnight's fast, by renewing its attacks upon the snails.

It has already been mentioned that the glow-worm is not the only member of its family that is found in this country. At Lewes and Hastings another and smaller species has been observed, which is called *Phosphænus hemipterus*. It is similar in shape to the glow-worm, but has considerably longer antennæ. The female is quite apterous, but the male differs markedly from our common species, in that wings are absent, and the elytra are very short, not much more than a quarter as long as the body. Moreover, they are pointed behind, and their inner edges do not meet, but gape apart like those of the oil beetle we described a short time ago. Curiously enough, in this species it is the male that is usually found; the female is either much rarer, or manages to keep itself out of sight, for it is very seldom met with. The male is usually found crawling about on walls. This insect is pretty widely distributed on the Continent, but in this country it has been observed only in the two localities above mentioned, though there seems no reason why it should not occur elsewhere.

THE DISTANCE AND MASS OF THE BINARY STARS.

By J. E. GORE, F.R.A.S.

IN a previous paper (KNOWLEDGE, November, 1891) I considered the mass and relative brightness of those binary stars for which a parallax had been found. In the present paper I propose to discuss the probable distance and mass of those binary stars for which a parallax has not yet been determined. The method of procedure I propose to adopt is to compute what is called the "hypothetical parallax" of the binary star—that is, its parallax on the assumption that its mass is equal to the mass of the sun—and then to find the stellar magnitude to which the sun would be reduced if placed at the distance indicated by this hypothetical parallax, assuming that the sun's stellar magnitude at its present distance is $-25{\cdot}5$. Comparing, then, the star's magnitude, as measured with the photometer, with the sun's reduced magnitude, it will at once appear whether the binary is brighter or fainter

than it should be if placed at the distance indicated by the hypothetical parallax. I have computed the hypothetical parallax and the corresponding magnitude of the sun for all the binary stars for which an orbit has hitherto been computed, and I find that in the great majority of cases the star is brighter than the sun would be if placed at the distance indicated by the hypothetical parallax. This fact would imply that most of the binary star systems —at least those with spectra of the solar type—have a smaller mass than that of the sun, and are at a less distance than that indicated by the hypothetical parallax. This will appear from the following consideration. If p be the parallax of a binary star, a the semi-axis major of the orbit in seconds of arc, P the period in years, m and m^1 the masses of the components, and M the mass of the sun, we have the formula $m+m^1=\frac{a^3}{p^3 P^2} M$, whence $p=\frac{a}{(m+m^1)^{\frac{1}{3}} P^{\frac{2}{3}}} M$. Now if $m + m^1 = M$, or the mass of the system is equal to the sun's mass, we have $p=\frac{a}{P^{\frac{2}{3}}}$, which is the well-known expression for the hypothetical parallax. But if $m+m^1=n$ M, we have, taking $M=1$, $n=\frac{a^3}{p^3 P^2}$. From this it follows that the larger the parallax p is, the smaller is the mass of the system, and conversely, the smaller the parallax the greater the mass will be. Now, as in most cases the binary is brighter than the sun would be if placed at the distance corresponding to the hypothetical parallax, it follows that to make the sun of equal brightness with the star it should be placed at a less distance than that indicated by the hypothetical parallax — that is, the parallax must be increased, and consequently the mass of the binary star diminished. This reasoning, of course, only applies to those binaries which have spectra of the solar type, for stars of the first or Sirian type are, as is well known, much brighter than the sun is in proportion to their mass.

Let us first consider the binaries having spectra of the solar type, in which I find some remarkable differences between the star's apparent brightness and the sun's corresponding magnitude, if we assume that they have the same mass as the sun. I have omitted those in which this difference does not much exceed two magnitudes.

γ Leonis.—This is the most remarkable of all the binaries, having spectra of the second or solar type. Its "relative brightness," calculated by a well-known formula, is very high, being about 93 times brighter than ξ Ursæ Majoris taken as a standard, and which has also a spectrum of the solar type, although slightly different according to the Draper Catalogue, the spectrum of γ Leonis being noted as of class K and that of ξ Ursæ as class G. According to an orbit computed by Dr. Doberck, the hypothetical parallax of γ Leonis is only 0·036″. Placed at this distance, the sun would shine as a star of only 8·29 magnitude. The magnitude of γ Leonis, as measured with the photometer at Harvard Observatory, is 2·24. There is, therefore, a difference of 6·05 magnitudes, which denotes that γ Leonis is about 263 times brighter than the sun would be if placed at the distance indicated by the hypothetical parallax. The sun placed at a distance corresponding to a parallax of 0·58″ would appear of the same brightness as γ Leonis. But if the star had so large a parallax it would probably have been detected ere this. With a parallax of 0·58″, I find that the mass of γ Leonis would be less than $\frac{1}{4000}$th of the sun's mass, which also seems improbable. It is, consequently, very difficult to give any satisfactory explanation of the great brilliancy of this binary star. The accuracy of the orbit computed for this pair (period 407 years) is of course very doubtful, as the arc described since its discovery has been small. Its slow motion, however, indicates that the period must be long. The spectrum is not exactly the same as that of the sun, and the star may be hotter and brighter.

π Cephei.—The spectrum of this star is, according to the Draper Catalogue, of the second type, but doubtful (H ?). According to an orbit computed by Prof. Glasenapp, its hypothetical parallax is 0·032″, which would reduce the sun to a star of magnitude 8·6. The star's magnitude measured at Harvard is 4·48, so that there is a difference of 4·12 magnitudes, denoting that the star—if of the same mass as the sun—is 44½ times brighter. To make the sun equal in brightness to the star, the parallax should be increased to 0·208″, and the mass of the binary system diminished to $\frac{1}{2\,3\,7}$th of the sun's mass. But as the spectra are not identical, perhaps the sun and π Cephei are not exactly comparable.

ω Leonis.—In this case the hypothetical parallax is, from Dr. Doberck's orbit, 0·022″, a parallax which would reduce the sun to a magnitude of only 9·36. The star's measured magnitude is 5·55, which gives a difference of 3·81 magnitudes. This would imply that the star is about 33½ times brighter than the sun, if both bodies were of the same mass. To make the sun equal in brightness to the star, the parallax should be increased to 0·127″, and the mass of the binary system diminished to $\frac{1}{1\,9\,5}$th of the sun's mass. The spectrum being, however, of class G of the Draper Catalogue, the sun being of class F, the two bodies are not perhaps strictly comparable.

β Delphini.—This is a binary star with a spectrum of class F, or that of the sun, so that the two bodies should be comparable in intrinsic brilliancy. From my orbit for this pair—which cannot be far from the truth—the hypothetical parallax is 0·052″, which would reduce the sun to a star of 7·49 magnitude. As the star was measured 3·74 at Harvard, we have a difference of 3·75 magnitudes, denoting that the binary—if of the same mass as the sun—must be nearly fifty times brighter. As the spectrum is of the same type this seems improbable, and we must conclude that the star's parallax is more than 0·052″. The sun, placed at a distance corresponding to a parallax of 0·292″, would shine as bright as the star appears to us. With this parallax, the mass of the binary would be reduced to $\frac{1}{1\,7\,7}$th of the mass of the sun. It seems improbable, however, that so comparatively large a parallax as 0·292″ should remain undetected.

τ Ophiuchi.—From Dr. Doberck's orbit of this pair, the hypothetical parallax is 0·033″. At the distance thus indicated the sun would be reduced to a star of 8·48 magnitude. The star's photometric magnitude is 4·93, which gives a difference of 3·55 magnitudes, denoting that the star would be—if of the same mass—about twenty-six times brighter than the sun. A parallax of about 0·17″ would make the sun equal to the star in brightness, and this parallax would reduce the mass of the binary to $\frac{1}{1\,3\,6}$th of the sun's mass.

ζ Aquarii.—This binary has the longest period yet determined, namely, 1578 years, according to Doberck. Of course, this great length of period renders the accuracy of the orbit very uncertain, but its slow motion and comparatively great distance between the components (a=7·64″) makes it an interesting object in the present discussion, particularly as its spectrum is that of the sun (F). With the above period and semi-axis major the hypothetical parallax is 0·056″, which would reduce the sun to a star of 7·33 magnitude. As the photometric magnitude of the star is 3·81, we have a difference of 3·52 magnitudes, or nearly the same as in the case of τ Ophiuchi. To reduce the sun to the brightness of the star it should

be removed to a distance corresponding to a parallax of 0·323″, and this would reduce the mass of the binary pair to $\frac{1}{102}$nd of the sun's mass. The uncertainty in the orbit, however, renders these results very doubtful.

ξ Scorpii.—From Schorr's orbit of the pair, I find a hypothetical parallax of 0·06″, which would reduce the sun to a star of 7·18 magnitude. As the star's photometric magnitude is 4·10, we have a difference of 3·08 magnitudes, denoting that the binary—if of the same mass as the sun—is about seventeen times brighter. A parallax of about 0·248″ would make the sun equal in brightness to the star, and this parallax would reduce the mass of the binary to about $\frac{1}{70}$th of the sun's mass. The spectrum is a doubtful one (F ?) of the second type, and perhaps the star may not be strictly comparable with the sun.

ι Leonis.—The hypothetical parallax derived from my orbit for this pair (the only orbit yet computed) is 0·07″. This would reduce the sun to 6·85 magnitude, and as the star was measured 3·98 at Harvard, we have a difference of 2·87 magnitudes, which indicates that the star is, for equal masses, about thirteen times brighter than the sun. To make the sun equal to the star in brightness, the parallax should be increased to 0·262″, and this would reduce the mass of the binary to about $\frac{1}{5\,2}$nd of the sun's mass. The spectrum is of the G class in the Draper Catalogue.

35 Comæ.—An orbit recently computed by me gives a hypothetical parallax of 0·045″, indicating a distance at which the sun would be reduced to a star of 7·8 magnitude. The star's measured magnitude being 5·08, we have a difference of 2·72 magnitudes, which makes the star twelve and a quarter times brighter than the sun if the masses were equal. A parallax of 0·158″ would make the sun equal to the star, and this would reduce the mass of the binary system to $\frac{1}{4\,3}$ of the sun's mass.

τ Cygni.—For this binary pair Mr. Burnham has lately computed an orbit, and found a period of 36½ years, with $a = 0{\cdot}94''$. This gives a hypothetical parallax of 0·085″. and at the distance indicated the sun would be reduced to a star of 6·42 magnitude. The star's photometric magnitude being 3·94, there is a difference of 2·48 magnitudes, which would make the star 9·8 times brighter than the sun. A parallax of 0·267″ would reduce the sun to the brightness of the star, and this would diminish the mass of the binary to $\frac{1}{3\,1}$th of the sun's mass. As the spectrum is of the same class (F) as the sun, the two bodies should be fairly comparable, but perhaps the stars composing the binary system may be slightly hotter, and of less density than our sun. This remark may also apply to ι Leonis and 35 Comæ.

The binary stars of the first or Sirian type are, of course, not comparable with the sun, as it is evident from the case of Sirius, and other stars of this type, that these stars are intrinsically much brighter in proportion to their mass than stars of the solar type. Of these Sirian type stars, the most remarkable is ϕ Ursæ Majoris. From Glasenapp's orbit for this binary pair, the hypothetical parallax is only 0·01″, which would reduce the sun to a star of 11·07 magnitude. As the star's photometric magnitude is 4·43, we have a difference of 6·64 magnitudes, denoting that the star is—if of the same mass as the sun—about 453 times brighter! As, however, we cannot compare its brightness with that of the sun, no estimate of its mass and distance can be made.

There is one binary star which forms a remarkable exception to those considered above. This is μ^1 Herculis. From the orbit computed by Leuschner (period 45·39 years; $a = 1{\cdot}369''$) the hypothetical parallax is 0·107″. At the distance indicated by this parallax the sun would shine as a star of 6·0 magnitude. As the magnitude of the binary pair is about 9·5, we have here an exception to the general rule—namely, a star *fainter* than the sun would be if placed at the distance indicated by the hypothetical parallax. The difference is 3·5 magnitudes, denoting that the sun is over twenty-five times brighter than the star, for equal masses. To reduce the sun to a 9·5 magnitude star, the parallax should be reduced to about 0·02″, and this would *increase* the mass of the system to 155 times the mass of the sun. The star being so faint its spectrum has not been determined, but the binary pair forms a distant comparison to μ^3 Herculis, the magnitude of which was measured 3·49 at Harvard. Both stars, although relatively fixed, have a common proper motion through space, a fact which suggests a physical connection. According to the Draper Catalogue, the brighter star has a doubtful spectrum of the second type (class I ?). It does not follow, of course, that the fainter star (the binary) has a spectrum of the same type. Indeed, its bluish colour would suggest a spectrum of the Sirian type; but if of this type, it is difficult to understand why it should be so faint. If the binary pair is physically connected with the brighter star, both objects probably lie at practically the same distance from the earth. The difference in their brightness—six magnitudes—is, therefore, very remarkable, and would be still more so if the brighter star were of the second type and the fainter of the first.

THE DEGENERATION OF HUMAN STATURE.

By MISS C. S. BREMNER.

THE question is one that not only takes us back to the dawn of history, but to prehistoric times. If we consult the sacred writings of any people, the sagas of northern races, the legends and traditions common among southern ones, we almost invariably find the same general impression, not infrequently a precise statement, that the human race is diminishing in stature. All the legends point to heroes and demigods of immense stature. Buckle alludes to the same fixed ideas in early Indian history. The early Aryans were much more virtuous and happy than we their degenerate descendants; their stature was more exalted; the ordinary duration of life among them was about eighty thousand years. If a person led a saintly life, his days might be as long in the land as one hundred thousand years. Indeed one king and saint (one wonders if they were much the same in the good old times) began to reign at the age of two million years; he reigned six million three hundred thousand years. At the end of that time he seems to have grown weary in well-doing, for he abdicated the throne, lingering on some one hundred thousand years longer.

In the earlier portion of the Pentateuch, the life of man, we are told, extended to nine hundred years and more. This figure gradually decreases until we reach the time of David, when it is taken for granted that the years of man are seventy. Of the stature of the early heroes of the Pentateuch nothing is said. About the time of Moses we read that "in these days there were giants on the earth, the sons and daughters of Anak." The spies who went up to view the land of Canaan report very quaintly: "There we saw the giants, the sons of Anak, which come of the giants; and we were in our own sight as grasshoppers, and so we were in their sight." In Moab, we are told, "the Emims dwelt there in times past, a people great, and many, and tall, as the Anakims; which were also accounted giants, as the Anakims." Isolated giants are frequently spoken of, such as Og, king of Bashan, Ishbi-benob, who hoped to have

slain David; better known than both these was Goliath, whose stature, we are told, was ten or eleven feet.

Nor were the Greeks of a parsimonious disposition when they described the strength and stature of their heroes. Homer grieved over the gradual levelling down of the men of his day. Hesiodus bewailed that his contemporaries had declined in stature compared with the men of the good old times. Herodotus, Pliny, Pausanias, and Plutarch have all given expression to a similar idea, the latter complaining that the rising generation resembled new-born babes. Virgil's opinion is well known. In one passage he says: "When the cultivator upturns with his plough the weapons and bones of his ancestors, he is dumbfounded, lost in admiration of their gigantic stature."

The results of recent scientific investigation neither tally with the ancient theory of stature degenerating, nor yet with the more modern one of a constant upward tendency. Dr. Rahon, a French scientist of considerable repute, has recently collected statistics on human stature, while working at the Musée Broca under Dr. Manouvrier, a well-known professor of anthropology. Yet, in estimating the value of the conclusions to which M. Rahon has come, it ought to be remembered that his investigations have been limited to one country—France. His master, Dr. Manouvrier, is the introducer of many corrections in the study of bones, both in the methods employed and in the co-ordination of calculations made, in scientific parlance, "the co-efficients of reconstitution." M. Rahon has based his calculations on some millions of prehistoric bones collected from all parts of France, and now preserved in the Paris anthropological museums.

To establish a term of comparison between men of former times and men living now, it was indispensably necessary to have precise knowledge of the height of the latter. Dr. Manouvrier, therefore, measured the bones of two hundred and five men and one hundred and nineteen women who had undergone dissection in the Paris School of Medicine. The average height thus obtained was 1·650 mètres for men, and 1·528 for women.

On the other hand, the average height of adult men measured in the French criminal identification department by M. Bertillon is 1·648 mètres, which is, moreover, the average French height, as ascertained in military recruiting. The criminal identification department gives 1·545 mètres as the average height of adult women.

Dr. Rahon's measurement of the bones of various prehistoric and ancient peoples supplies an interesting comparison. He studied, in succession, bones of the quaternary, neolithic, proto-historic periods, and of the Middle Ages, with the following results:—

1.—QUATERNARY PERIOD.
5 male cases, average height 1·629m.

2.—NEOLITHIC PERIOD.
429 male cases, average height 1·625m.
189 female cases ,, ,, 1·506m.

3.—PROTO-HISTORIC.
215 male cases, average height 1·662m.
39 female cases ,, ,, 1·539m.

4.—PARISIANS OF THE MIDDLE AGES.
(Cemetery of Saint Marcel.)
294 men, average height 1·657m.
101 women ,, ,, 1·555m.
(Cemetery of Saint Germain-des-Prés.)
140 men, average height 1·656m.
46 women ,, ,, 1·555m.

What conclusion, therefore, can be drawn from these figures based on serious and methodical investigation? Undoubtedly, we may conclude that all those who hold the opinion that our stature is appreciably smaller than that of our ancestors, labour under a delusion.

As a result of Dr. Rahon's investigations it may be definitely stated:—

(1) That the skeletons attributed to the most ancient representatives of the human race belonged to individuals of stature at most normal, if not small.

(2) That neolithic peoples—of the polished flint period, dating back more than three thousand years—constantly show us medium stature, lower than our present average height.

(3) That the various proto-historic peoples, Gaul, Frank, Burgundian, Merovingian, present an average stature superior to that of French people of to-day, but not so great as we have been led to expect; as a matter of fact, not exceeding 0·015 mètre.

In short, in spite of the armour of the Middle Ages, we must come to the conclusion, if we may trust to Dr. Rahon's statistics, that height has almost inappreciably diminished by 0·007 mètre. We have, therefore, no cause for discouragement; we need hardly cry out "degeneration" yet. If we diminish no more than this in the centuries, we have no reason to fear that our great-grandchildren will be dwarfs.

So far as women are concerned, the figures seem to point to an appreciable diminution in the difference of the stature of the sexes. The difference between neolithic man and woman is calculated at 0·119 mètre; proto-historic, 0·123; Middle Ages, 0·102; modern times (dissection), 0·122; ditto (criminal investigation), 0·103.

MECHANICAL FLIGHT.

By THOMAS MOY.

MR. MAXIM having had his *little* joke, which was proof against bullets, and his *big* joke, which was proof against soaring, and the excitement anent both performances having now subsided, it may be opportune to take a calm bird's-eye view of the latter subject as it stands.

The two greatest obstacles in the way of the accomplishment of mechanical flight have been the balloon and the screw propeller.

The "life" of a balloon depends upon the quantity of ballast which it can carry, in addition to its live load. Gas must be lost with every variation of height and change of temperature; and this waste must be counteracted by throwing away ballast. For want of this knowledge, novices have sometimes gone up like a rocket and come down like a stick. A free balloon is integral with the air in which it is suspended. If a candle were lighted in the car, in a wind of fifty miles an hour, the candle would burn as steadily as in a room, so completely is it at the mercy of the wind.

The attempts to stiffen balloons and other gas bags, to fit them for propulsion, have all been failures. When I was in Vienna in 1873 — exhibition year — I attended meetings of the Aëronautical Society there, and found several ingenious attempts had been made to stiffen the fabric, to enable balloons to retain their shape, under propulsion, but the extra weight was always too great.

Dupuy de Lôme's expensive experiment in 1872 stands out as a warning. The hydrogen gas alone, to fill it once, is reported to have cost £360, and although the gas bag was pointed at each end, and was driven by a screw, it was only able to deviate five degrees from the direction of the

wind, in a journey of ninety miles. The whole of the gas had then to be wasted, the bag and apparatus packed up, and all returned to Paris by railway. That was a long way off the accomplishment of aërial navigation, and we are not likely to get much nearer by means of propelled gas bags. In spite of the many failures in this direction, many people look upon it as the only feasible plan, and the United States Patent Examiners have refused Mr. Maxim a patent because he does not describe and claim a gas bag in his combination.

Just as one class of experimenters have inscribed "Finality Jack" upon the gas bag, so another and larger class have come to the conclusion that the screw is the best and only available propeller; among the rest, Mr. Maxim and Lord Kelvin.

This mistake has arisen from its *partial* success in water, in the propulsion of steam ships. I say "partial" success because there is such a thing as "slip." This slip of the screw is bad enough in water; it is ruinously wasteful in attempts at mechanical flight. It is the delusive estimate of the efficiency of the screw propeller in air which caused someone to express himself as follows, in a daily newspaper: "Inventors are constantly, to the amusement of practical engineers and mechanicians, inventing forms of flying machines, oblivious to the fact that every engineer of experience could produce at a few hours' notice the necessary form of machine, when the, at present, undiscovered and necessary materials are found." I withhold the name. This man evidently had settled it in his mind that all the apparatus required consisted of an aëroplane, screws, and a *light* motor; the error into which Henson fell in 1842, and Maxim fifty years after.

The following extract from a scientific journal is still more amusing:—"It is true that Mr. —— has recourse to a whirling propeller, which is about as foreign to a natural device as anything could well be. The neglect of rotary motion as a means of propulsion (except in the transference of wave motion) is one of Nature's most unaccountable proceedings. If it were not for the beautiful efficiency of her nerve and muscle motors, perhaps she would be driven to the continuous effort of the screw or wheel rather than the flappings and reciprocations of wings and legs she now adopts."

The assurance of this critic of Nature's methods will be obvious, if we substitute the Creator of Nature for "she."

One gentleman became so enamoured of the aërial screw, some few years ago, that he actually proposed to drive ships with aërial screws instead of marine screws. It is surprising that he did not propose to drive railway trains by the same means.

Now what is *slip*? Suppose a boat, when travelling in water at eight feet per second has a resistance of 62·5 pounds. Fit this boat with a small steam engine and a drum. Let this drum wind up a rope, the other end of which is made fast to some stationary object. Disregarding the weight of the rope, we may assume it to be five miles long. With a strain upon the rope of sixty-two and a half pounds exerted by the engine, the boat would cover the distance of five miles in an hour. There would be no *slip*. Now, instead of making the rope fast to a fixed object, let it be attached to a floating board, having a vertical immersed surface of one square foot. A strain or pull upon this surface of sixty-two and a half pounds would produce a speed of eight feet per second of both the boat and the board—that is to say, the board would "come home" towards the boat at the same speed that the boat would travel, thus winding in the rope at sixteen feet per second, and the rope would be all wound on the barrel when the boat had travelled but two and a half miles. In this case, half the power would be wasted in slip. For certain well-known reasons, the screw propeller is more efficient than a mere flat board would be, but the slip of the screw in water generally causes a loss of twenty to twenty-five per cent.

A screw bolt driven into a nut has no slip. A marine screw propeller, working in a *water nut*, produces slip and consequent waste of power. The *air nut*, however, is excessively yielding, and the slip is far too great for the propulsion of a successful aërial machine.

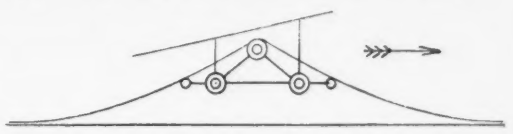
In the sixth annual report of the Aëronautical Society of Great Britain (1871) will be found a calculation by Mr. Wenham of the slip, with vertical screws in the air, in which he estimated that twenty-two horse-power would be required to raise a weight of two hundred pounds. My experiments have given better results than this, but even five horse-power to two hundred pounds indicates great loss by slip.

Comparing Henson's device of 1842 with Maxim's of 1892, one sees very little advance in the latter. Henson placed the axles of his screws in line with his aëroplane, and Maxim places his lower down. Of the two, Henson's appears the most logical arrangement. Henson and Stringfellow used cop-tube boilers, to prevent priming. Maxim's first boiler consisted of a crowd of tubes, which I know from experience would get uncomfortably hot; and he afterwards reduced the number considerably, and brought his boiler to a less complicated state, something like my 1877 patent. Mr. Henson's machine failed for want of propulsive power, due to slip. When started it slid backwards and injured its tail. Mr. Maxim's has failed for the same cause.

But it may be thought that I used common screws in 1875; this would be a mistake. My 1871 patent expressly describes *feathering* screws—that is, the pitch of the blades was very much greater on the descending side than on the ascending side, whereby a lifting force was obtained on both sides of the axle; one derived from the downward action, and the other from the forward motion.

My experiment with this machine was very much handicapped by having to sustain half the weight of two guide ropes, each one hundred and fifty feet long, and the reduction of power from the forward lamps extinguishing the lamps at the rear of the boiler. The machine was afterwards destroyed in a stiff gale, while moving it from the Rotunda in the Crystal Palace grounds to a new shed near the Penge entrance. I afterwards fitted two horizontal screws, twelve feet diameter, to the three-horse engine; but these only gave an upward thrust of one hundred and twenty pounds, thus again proving the importance of loss by slip.

I will conclude by suggesting that Mr. Maxim should take his machine to (say) Salisbury Plain; lay down his piece of railway without the top rails; lay down a rope on the ground, the longer the better; unship his screws and mount a drum, as shown in the sketch, passing the rope two or three times round the drum, and driving the drum by his engines. By this arrangement he will avoid slip, and, if his engines give out anything like three hundred horse-power, his machine will rise a short distance from the ground, as shown. The weight of rope looped up from the ground will limit the height, and the two small guide pulleys, fore and aft, will secure horizontal stability.



NOTICE.

With very great regret the announcement has to be made that Mr. Ranyard, owing to serious illness, has been unable to edit this issue. Mr. Ranyard has been brought to a very low and weak condition, and as he recovers a sea voyage will be necessary, but he hopes to resume his labours before very long. In the interim, Mr. E. W. Maunder has kindly offered to supervise the astronomical pages of KNOWLEDGE.

THE CENTRAL EQUATORIAL REGION OF THE MOON.

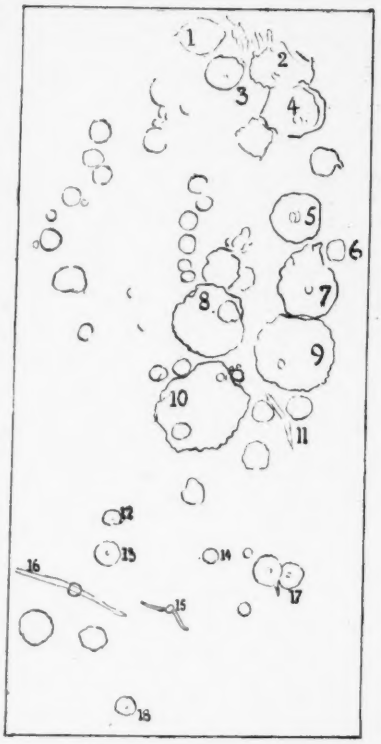
By T. GWYN ELGER, F.R.A.S.

THE contrast between the northern and southern hemisphere of the moon, as regards the number and size of large ramparted enclosures, is evident on glancing at any map or photograph of its visible surface. Though the former includes many notable objects of this description, only a few of them can compare in dimensions or complexity of structure with those on the opposite side of the lunar equator. A distinction almost as striking exists between the two quadrants of this southern hemisphere, the south-western containing an almost endless variety and bewildering number of formations of a type which is much more scantily represented in the other quarter. The inequality in the distribution of the maria, or so-called "seas," is also very remarkable. If a great circle is drawn from about N. lat. 20° on the western limb, through the intersection of the first, or central, meridian with the equator, to the corresponding S. lat. on the eastern limb, the greater portion of the superficies north of this line consists of low-lying dusky plains, whose monotony is often unrelieved by any conspicuous object, while the region south of it, very distinctly brighter, is the area on which the results of those volcanic forces which have given to the moon its extraordinary aspect are developed to the greatest extent.

The beautiful plate which accompanies this paper, though only including a portion of the surface extending from S. lat. 30° to about 20° on the north side of the equator, admirably illustrates the distinction which has been referred to. Ptolemaus, the great central ring-mountain so prominently represented thereon, with the chain of irregularly-shaped formations running north from it, and the apparently inextricable confusion of *bizarre* groups flanking it on the west, may thus be compared with the smaller and generally different features portrayed on the northern half of the picture.

Ptolemaus is undoubtedly one of the most perfect and typical examples of a certain class of formations, termed "walled-plains," which can be found on the moon, and from its position, near the centre of the disc, can be more conveniently scrutinized and studied than almost any other. These formations differ from many which often bear a superficial resemblance to them, not only in extent, but in the hypsometrical relation which exists between their interior, or, as selenographers term it, "the floor," and the region beyond the limits of the circumvallation. In most other enclosures this floor is depressed, sometimes to the extent of many thousand feet, below the outside region, but in the walled-plain there is seldom any appreciable difference in level between the interior and exterior. Less marked, but still characteristic of these objects, is the nature of the rampart and its slopes, within and without. In many of the so-called ring-mountains, the latter are only slightly inclined outside, rising to the summit of the wall with an extremely gentle gradient, while they descend to the floor with a very steep declivity. The border of the walled-plain is also, as a rule, less continuous, being more frequently interrupted by gaps, crossed by transverse valleys and passes, and broken by more recent craters and depressions.

To return, however, to the notable object which figures so prominently on the plate. In order to appreciate its actual size and the scale of its surroundings, it must be remembered that a distance of one hundred and fifteen miles intervenes between the sides, or rather more than that from London to Birmingham; so that the whole of the principality of Wales, with one or two of the bordering counties in addition, could easily be accommodated within its limits. In fact, its dimensions are such that, though there are peaks on the rampart rising to four thousand, five thousand, and even six thousand feet; if it were possible for an observer to be stationed near the centre of this great amphitheatre, he might well imagine that he was standing on a boundless plain, for, except at one or two points on the west, there would be nothing to break the monotony of the prospect.



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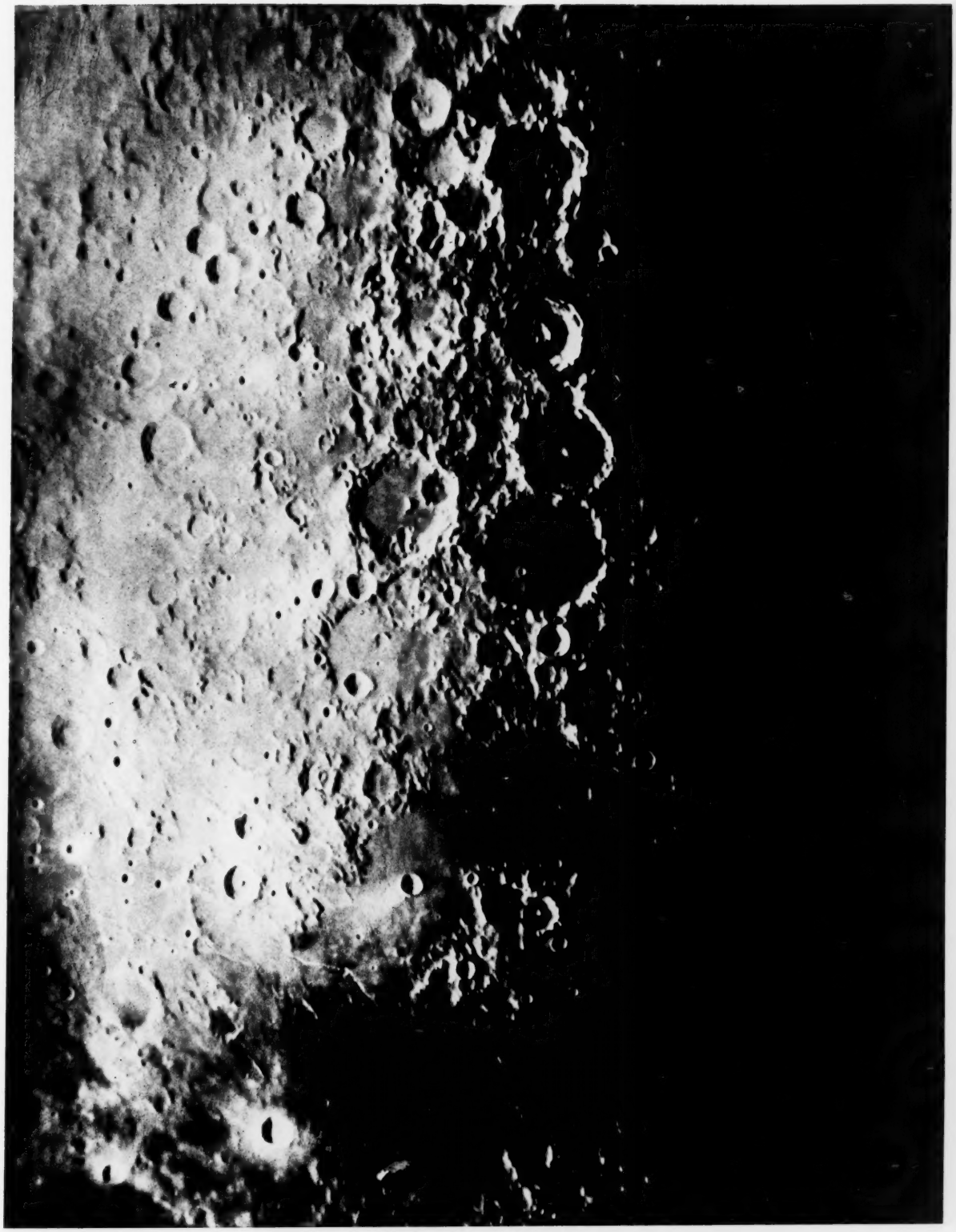
At the particular phase represented in the plate, the sun has not long risen on Ptolemaus and the chain of great rings south of it; hence its rays fall very obliquely on the enclosed plain, and reveal details which, a few hours later, would be wholly invisible. Among the most noteworthy of these, is a number of shallow, circular, saucer-shaped depressions, about four or five miles in diameter, confined for the most part to the eastern half of it. Owing to their insignificant depth, they are so evanescent that, unless they are looked for at a very early stage of lunar sunrise, it is impossible to see them, though minute craters found within them can be traced long after they have disappeared. Objects of this kind, though not uncommon on the "seas," are nowhere so closely aggregated as here. They impress one with the idea that they represent old crater-rings, which are covered and partially

SOUTH.



WEST. EAST.

SUNRISE ON PTOLEMAUS.

From a Photograph by the Brothers HENRY, with the thirteen-inch Photographic Refractor of the Paris Observatory.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

XUM

XUM

obliterated by the grey material (whatever this may be) of which the floor of Ptolemaus and other similar formations, including the "seas," are composed, which was once most probably of a semi-fluid or viscous consistency, though now probably everywhere consolidated. On the north-western side of the interior stands the only conspicuous object upon it, a bright deep crater about four miles in diameter; and south of it two large obscure rings, extending to the border, one of which in the plate is almost wholly obscured by its shadow. This crater, including its slopes, cannot be less than seven or eight miles across, and thus occupies an area fully as large as Vesuvius, though it does not resemble it in other respects—its flanks being much steeper and the opening on the summit more than double the diameter of the old crater-ring of Somma. Viewed under a somewhat higher sun than obtained when MM. Henry's photograph was taken, the interior of Ptolemaus is seen to contain a large number of small craters; and, under a still more vertical illumination, to be traversed by a curious arrangement of light streaks, the nature of which still remains enigmatical, though the fact that they are invariably associated with small craters, both here and elsewhere, points to an intimate physical connection.

Among other features in the vicinity, beautifully displayed in the plate, is a great valley, flanking on the west the bright circular formation Herschel. This elongated gorge, eighty miles in length and in places fully ten miles in width, is one of the finest on the moon, and is, perhaps, only surpassed by two others, one being the valley east of Ukert, and the second the great wedge-shaped depression that cuts through the lunar Alps west of Plato, which is shown with remarkable distinctness in a photograph of the moon two hundred and forty hours old, by MM. Henry, published in KNOWLEDGE in December, 1890. Herschel is a typical example of the "ring-plains," by far the most numerous of the large crater-like objects on the moon. Here we have a depressed floor, and a nearly circular, continuous and massive wall, surmounted by peaks considerably loftier than any on the circumvallation of Ptolemaus, which it adjoins. Hipparchus, whose low irregular outline can only be well traced under a rising or setting sun, comes out so plainly that the isolated sections of its apparently ruined border can be seen nearly as well-defined as they are in the telescope under good atmospheric conditions.

No portion of the moon, excepting in high latitudes in the south-western quadrant, exhibits to such an extent the mutual deformation and interference of formations, or so many departures from circularity, as that under consideration. There is scarcely a ring-mountain or enclosure of any description that does not appear to have been more or less modified in form by the propinquity of neighbouring objects. On the northern side of the equator very few examples of this appearance are found, except in the rugged highlands and in the vicinity of the lunar north pole, where the enclosures are more crowded. The region between Albategnius and Purbach is particularly noteworthy and suggestive on this account, as including a great number of small overlapping rings and fragmental craters, many of them grouped and massed together without any apparent governing principle, though on a closer scrutiny a tendency to a more or less linear arrangement in a meridional direction can be traced. This tendency is much more obviously displayed in the curious chain of seven or eight little misshapen ring-plains extending in a sinuous line from the foot of the *glacis* of Albategnius, towards Purbach. It can hardly be questioned that, like the smaller crater-rows, so plentifully found in almost every part of the moon, they occupy the site of a long-extending crack or fissure. It will also be noted that, with two or three exceptions, they have prominent central hills, and that the most southerly constituent of the chain consists of at least four inosculating rings of unequal size.

The sharpness and general excellence of MM. Henry's photograph is otherwise manifested by the ease with which many of those delicate cracks or furrows called "rills" can be followed. The well-known cleft passing through Hyginus, with its local expansions and contractions, is admirably distinct. The more attenuated but longer object of the same class running towards the east from Ariadæus, and the very remarkable group of rills, all of considerable delicacy, situated on the grey plain west of Triesnecker are also plainly traceable.

Letter.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

ON THE ELECTRIC ORIGIN OF THE SOLAR CHROMOSPHERE.

To the Editor of KNOWLEDGE.

Dear Sir,—The October number of KNOWLEDGE contains the summary of Mr. Evershed's very interesting experiments on the question whether gases can become luminous by heat alone. This question is a very difficult, and a very important one too, and the results given by the numerous observers who have studied it are not alike. Two leading spirits, Profs. Helmholz and Stokes, have set forth upon this subject quite different opinions.

From all the experiments it may be concluded, I believe, that gases can emit from the single elevation of temperature a continuous spectral light, as the solid and liquid bodies do; but does light, in the same conditions, show the characteristic lines? Some doubts are still allowed, for sodium vapour, the only one that has been studied, contains, as a rule, hydrogen in great quantity, and therefore is not absolutely pure; besides, the recipient used is either attacked by it, as porcelain, or else is porous for the gases of the flame, as hot iron.

These objections are raised with a view to obtaining explanations.

However, Mr. Evershed concludes from his experiments on sodium vapour that all the gases may generally give their characteristic vibrations by heat only, and he immediately applies this result to the solar chromosphere, the light of which might be due to the intense heat of the disc. Mr. Brester explains the chromosphere by chemical combinations, but, for my part, I have already owned the necessity of an electric action (1). As I have got to this result without touching the great question of the luminescence of the gases, I think I must expound it with some details.

The characteristic lines of the gases are due either to heat (I admit that heat may suffice) or to a chemical action, or to an electric action. But, *a priori*, chemical and electric actions bring in something more, that is, a chemical combination, an electric and magnetic field, and one understands that they may be attended by special vibrations. This induction is confirmed by all the facts of spectral analysis. With the same body, electricity gives lines that a chemical flame does not show; moreover, the induction spark does not give the same spectrum as the electric arc, and the addition of a condenser in the circuit of the spark causes the production of new and special lines.

(1) *Comptes rendus de l'Academie de Paris*, 27 November, 1893. KNOWLEDGE, December, 1893.

In that point of view, the characteristic hydrogen spectrum is particularly remarkable. It has never been obtained in chemical flames, even the hottest, and although thousands of attempts have been made under the most varied conditions(2). On the other hand, the smallest induction coil gives it easily, and, a point well worth noticing, the electric arc gives it also, but feeble and with difficulty; so that electric interference, even with a notable tension, appears necessary to its formation(3).

Now then, all the points of the chromosphere show this characteristic spectrum of hydrogen, so that we must conclude, as Mr. Fizeau, and, I believe, Dr. Huggins do, that the chromosphere is an electric flame; or, at least, this conclusion, which rests on a great number of varied experiments, is by far the most probable, in the actual state of our knowledge. But this point once admitted, I have been somewhat puzzled for a moment, because the electric flames of our laboratories have not that same shape, and spring up generally between two poles. Now, in the present case, where are the poles?

Quite naturally I have thought of the earth, which is the only celestial body we know (yet imperfectly), and which being a cooled sun, must, in all likelihood, present on a smaller scale the same phenomena as the incandescent stars do, on a larger scale.

And I have immediately been struck with the analogies between the solar chromosphere and our own atmosphere, looked upon from the point of view of its electric state. This odd and as yet unexplained phenomenon of the rapid increase of the electric potential with the altitude(4), which constitutes what is called atmospheric electricity, is general for all the earth. The fall of potential, as we know, is stronger in tropical regions; stronger also, all the other conditions being the same, in mountainous regions.

Now in the solar atmosphere the electric distribution is also the same, the fall of potential in each point being measured by the intensity of the light set forth; indeed, the chromosphere is brighter in the region of the spots, and, above all, shows very clear maxima over the faculæ which are just the lofty part of the surface of the sun. Then both electric phenomena have the same ways in both atmospheres, and this unexpected verification strongly confirms the admitted conclusion.

However, the terrestrial atmospheric electricity, the cause of which is still unknown, is probably due to the evaporation, the condensation and the relative motions of the atmospheric gases. The same causes exist also for the sun, and in larger proportions; and one may comprehend that the effects must also be more considerable.

One single remark more and I have done. The electric explanation of the chromosphere agrees very well with all the mechanical theories of the sun, and especially with that of Mr. Faye, which, in my judgment, best explains the whole of the phenomena. Likewise, in the study of the terrestrial tempests, the motions of the air, and the electric variations that attend them, are generally studied apart. In reality, the advancement of our knowledge of the solar atmosphere is closely bound up with the progress of terrestrial meteorology.

Yours truly,

H. Deslandres.

The Observatory, Paris.

(2) Prof. Hartley, in a recent study on the spectrum of the Bessemer flame (*Proceedings of the Royal Society*, Vol. LVI., No. 337, p. 193), has made this very interesting observation: "In the first period of the blow, the C line of hydrogen, and apparently the F line, were seen reversed during a *snow-storm*." Now, Prof. Hale, in the last number of *Astronomy and Astro-physics*, page 771, relates this new experiment and adds that the fact, if substantiated, is contrary to the electric explanation of the chromosphere. I have not the same opinion for several reasons:—1st, In this one experiment the rays are not brilliant, but black and reversed, which is not exactly the same; 2nd, a very strange condition, difficult to realize, the coincidence with a snow-storm appears necessary. In a snow-storm the differences with the ordinary conditions are not in the composition of the gaseous air, which is only relatively dry, but in the particular state of atmospheric electricity; so that electricity seems yet to bear a predominant part in the phenomenon. But, was snow falling on the flame? The note of Prof. Hartley gives no details, and the complete discussion is therefore difficult. In fact, till further experiments, I maintain my first conclusions; and this curious observation, such as I have understood it, suggests to me only the idea to study the Bessemer flame in various electric fields, in conditions as similar as possible to those of a snow-storm.

(3) The intense chromosphere lines H and K of calcium confirm the result to a certain point; very feeble in the chemical flame, where Prof. Hale has recognized them, they are strong enough in the electric arc, and very strong in the induction spark, according to the experiments of Prof. Lockyer. The gradation is the same if we notice that chemical flames are the seat of weak electro-motive forces. We see that the production of these lines seems to require, as the electrolysis of the saline solutions, the use of a minimum number of volts; a small number for calcium, but a high one for hydrogen

(4) The difference of potential between the top and the bottom of the Eiffel Tower is often 10,000 volts.

Science Notes.

The Christmas course of lectures, suitable for children, at the Royal Institution, will be delivered by Prof. J. A. Fleming, F.R.S. The subject will be "The Working of an Electric Current," and the first lecture will be delivered on December 27th, at three o'clock.

Our contemporary *Nature* has completed its fiftieth half-yearly volume. Prof. Huxley wrote the first leading article in 1869, and he has also written the leading article for No. 1305, vol. 51, November 1st, in which he shows how firmly grounded is the theory of evolution.

The Museum of La Plata will shortly issue the second part of Mr. Lydekker's memoir on the fossil vertebrata of the Argentine Republic. It will be illustrated by over sixty folio plates, and deal chiefly with the Edentate mammals.

Nature for November 15th reproduces from *La Nature* some beautiful figures produced from ink, by Dr. E. Frouessart. A drop of ink is allowed to dry on a slip of glass, and observed under a microscope. They belong chiefly to the cubic system, and the writer of the original paper suggests that they are magnetic oxide of iron. But this question is not settled, they may be iron-disulphide.

Talking of "extinct monsters," it may be just as well to remind our readers that the animals so humorously introduced into *Punch's* "Prehistoric Peeps," by the artist, Mr. E. T. Read, are not in all cases founded on fossil remains, though many of them are. Truly, there are more things in Mr. Punch's mind than are dreamed of in our geological philosophy!

The German Emperor has lately presented to the Berlin Natural History Museum a very fine specimen of a Plesiosaurus skeleton (the first ever found in Germany), in which part of the outline of the creature is preserved on the rock, chiefly about the tail. It has been named after the Emperor by Prof. W. G. Dames, of Berlin, who will in February lecture on it to the Academie. The lecture will afterwards be published with a plate.

[The plate representing the "Daddy long-legs" in the November number of Knowledge was taken from a lantern slide kindly lent by Messrs. Newton & Co.]

The filtration of water, on a large as well as on a small scale, has acquired quite a different significance since the bacteriology of water has sprung into existence. (Surgeon-Major Johnston's short treatise on "the relative efficiency of certain filters for removing micro-organisms from water.") He has examined the Atkins' patent water filter, Maignen's table "filtre rapide," and the Nordmeyer-Berkefeld filter, and the Pasteur-Chamberland filter. The first two he considers useless for sterilizing water. The Pasteur-Chamberland filter is, in his opinion, the best and only one on which reliance can be placed for permanently sterilizing water. The investigations were carried on in the Public Health Laboratory of Edinburgh University.

Natural Science for the last two months gives some very interesting facts with regard to the way in which animals can gradually adapt themselves to new conditions, even when those conditions are at first fatal. From an account in the *Pittsburg Dispatch*, it appears that in the cold-storage warehouses in Pittsburg there were originally no rats nor mice. The temperature in the cold rooms was too low. But after a few months rats were at work in the rooms where the temperature was constantly kept below the freezing point, and they were clothed in long and thick fur. Cats were, therefore, turned loose in the cold rooms, but they pined and died. At last a cat with unusually thick fur was found which thrived there, and by careful nursing, a brood of seven kittens was developed. They have been distributed among other cold-storage houses of Pittsburg, and have created a peculiar breed of cats adapted to the conditions. The cats are now so acclimatized that they cannot live in the open air during the hot season.

"From the Greeks to Darwin; an outline of the Development of the Evolution Idea," is the title of an instructive work by the well-known palæontologist, Prof. H. F. Osborn, of the Columbia University, New York. Evolution, as a natural explanation of the origin of the higher forms of life, may have succeeded the old mythology in Greece, and *appears* to have first developed from the teachings of Thales and Anaximander (B.C. 611-547) with those of Aristotle. This great philosopher had a general conception of the origin of higher species by descent from lower species, and he even stated the theory of the survival of the fittest, though rejecting it as an explanation of the evolution of adaptative structures. He also believed that there was no fortuity in evolution, but that the succession of forms of life was due to the action of an internal perfecting principle originally implanted by the Divine Intelligence. What is this idea but the modern "law of progress," so strongly proved by the discoveries of palæontology? We would, however, humbly suggest that in these matters, as in others, the Greeks took their teaching from Egypt, where the problems of life and of creation had been deeply pondered over and partly explained to initiates of their sacred mysteries.

We have received a specimen from Messrs. Newton & Co. of their "spectrum top," which consists of a disc, half of which is white and half black. Over the white half are four groups of concentric lines. Upon being spun the black disappears, and the whole face is covered by four sets of circles, each of which assumes to the eye a peculiar tint. The hues appear to be dark from the centre when the top is spun from the right, and lighter when spun from the left.

Notices of Books.

By Order of the Sun to Chile, to see his Total Eclipse, April 16th, 1893. By J. J. Aubertin. Pp. 152. (London: Kegan Paul, Trench, Trübner and Co., 1894.) To the casual reader of astronomical literature who desires to know how an eclipse expedition appears to a layman's mind, we commend Mr. Aubertin's narrative. The author is an enthusiastic observer of the progress of astronomy, and, though in the evening of life, he journeyed to Chile in April, 1893, in order to witness the most impressive of celestial phenomena—a total eclipse of the sun. And just as an onlooker sees more of a fight than any of the combatants, so an intelligent spectator can take in the astonishing beauty of a solar eclipse better than the astronomer whose whole being, during totality, is wrapt up in the photographic camera or spectroscope of which he has charge. Mr. Aubertin was fortunate in selecting Chile as his destination, for he was not only able to observe the eclipse in all its fulness, but could also watch the proceedings of Prof. Schaeberle's party. His book contains a fine photograph of the professor, and four other plates—one representing a symmetrical corona of the familiar "Catharine wheel" type. After the eclipse had taken place, Mr. Aubertin made a pilgrimage to Arequipa, La Paz, and Cuzco, then to Lima and San Francisco, and then he crossed the line (for the sixteenth time) and returned home. The incidents of his journeys on sea and land are described with a certain amount of pleasantness, but we think the book will only be appreciated by a limited circle of readers. It will be more interesting to the author than to anyone else.

Forest Birds: their Haunts and Habits. By Harry F. Witherby. Pp. 98. (London: Kegan Paul, Trench, Trübner & Co., 1894.) Mr. H. F. Witherby's papers on popular natural history are well known to our readers. In the dainty little volume under review, some of these papers are printed with others contributed by the author to *Science Gossip;* the whole collection forming an interesting account of the haunts and habits of eight species of forest birds. The chapters of the book are not, however, merely reprints of articles, but rather the original papers rewritten for publication in book form. Mr. Witherby writes easily, clearly, and with the accuracy that comes from personal observation of the birds he describes. His book is embellished with thirty illustrations, most of them full-page plates, for which we have nothing but praise. They are among the finest specimens of process blocks that we have yet seen, and the paper upon which they are printed brings them out perfectly. The book is attractive as well as instructive, and is just the sort of volume to present to young beginners of the study of Nature, while children of an older growth will derive profit from its perusal.

Practical Methods in Microscopy. By Charles H. Clark, A.M. Pp. 210. (Boston: D. C. Heath & Co. London: Isbister & Co., 1894.) This is a practical handbook to the microscope, and, as a book containing descriptions of the many processes connected with microscopical researches, couched in simple language, and suitable for beginners and private workers, we heartily welcome it. The methods described are workable, and they refer to many branches of scientific study. The preparation and observation of sections of plants, animal tissues, and rocks are fully treated, as well as the preparation and examination of crystals and bacteria. There is also a chapter on photo-micrography. The theoretical principles involved in the construction of the microscope are briefly and accurately explained, and also the principal phenomena of polarized light, so far as they have

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practical application in the use of the microscope. These will lead the student to an intelligent understanding of the instrument he uses. The book is illustrated with forty figures in the text and seventeen fine reproductions of photo-micrographs. It is a work such as should be in the hand of everyone who purchases a microscope for serious study. There are several important treatises on various branches of microscopy, and many little books of mediocre quality, but we know of no volume so suitable for the self-taught student as the one before us.

Lectures on the Darwinian Theory. Delivered by the late Prof. A. Milnes Marshall, F.R.S.; edited by C. F. Marshall, M.D., B.Sc. Pp. 228. (London: David Nutt, 1894.) Of the late Prof. Milnes Marshall it may be truthfully said, as he himself said of Buffon, "he led many to think about and take an interest in natural history, and to add to it by their own observations, who would not otherwise have done so." An original thinker, an eminent investigator, a lucid writer, and an eloquent lecturer, he was an ideal exponent of scientific truths. The series of lectures recorded in this volume were delivered in connection with the Extension Lectures of the Victoria University during 1893, and they really constitute the most entertaining description of Darwinism that it is possible to obtain. The work opens with a historical account of the theory of evolution, and then in turn come artificial and natural selection, the argument from palæontology, the argument from embryology, the colours of animals and of plants, objections to the Darwinian theory, the origin of vertebrated animals, and the life and work of Darwin. Prof. Marshall had a thorough grasp of his subject, and he was an earnest disciple of Darwin. If he had lived to see the present volume through the press, some portions of it would doubtless have been amplified and altered; but even as it stands it is a worthy monument to his brilliant qualities, and an excellent statement of the development of the theory of evolution.

By Moorland and Sea. By Francis A. Knight. Pp. 215. (London: Elliot Stock, 1893.) Gentle reader, you should get this book. It is a book to read when light mental refreshment is required; a book to pick up when the dry bones of science have begun to pall upon your appetite; when you have had enough instruction and want to be entertained. The author is a keen and sympathetic observer of Nature—a naturalist with poetic fancy like Gilbert White and Richard Jefferies. There are now many writers on what may be termed the poetry of science, but none write more agreeably than Mr. Knight, or express their thoughts in a more attractive style. We have only one word of objection to this collection of papers originally contributed by the author to various journals; it is, that the two or three papers on subjects not connected with natural history would have been better omitted.

BOOKS RECEIVED.

A Treatise on Chemistry. By Sir H. E. Roscoe, F.R.S., and C. Schorlemmer, F.R.S. Vol. I., The Non-Metallic Elements. (Macmillan & Co.)

A Laboratory Manual of Organic Chemistry. By W. R. Orndorff. (D. C. Heath & Co.)

Physiology for Beginners. By M. Foster, M.A., M.D., F.R.S., and Lewis E. Shore, M.A., M.D. (Macmillan & Co.)

Travels with a Sunbeam; or Elements of Astronomy. Parts 1 and 2. By Arthur Z. Dadi. (Birmingham; W. G. Moore & Co.)

By Vocal Woods and Waters. By Edward Step. (Bliss, Sands & Foster.)

On Pedal and Antipedal Triangles; being an attempt to investigate the Laws of their Evolution. By A. S. Ghosh, F.R.A.S. (Patrick Press, Calcutta.)

First Things First. By the Rev. G. Jackson, B.A. (Hodder & Stoughton.)

Life and Mind; on the Basis of Modern Medicine. By Robert Lewins, M.D. (W. Stewart & Co.)

The Vaccination Question. By Arthur Wollaston Hutton. (Methuen & Co.)

Brief Notes on the Physical and Chemical Properties of Soils. By R. Warington, F.R.S. (Chapman & Hall)

Science for All. Part 58. (Cassell & Co.)

The Royal Natural History. Edited by Richard Lydekker, B.A., F.R.S. (Warne & Co.)

The Review of Reviews for November. (125, Fleet Street, E.C.)

The Eighth Annual Report of the Société Astronomique de France.

The American Geologist. (The Geological Publishing Co., Minneapolis).

The Journal and Transactions of the Royal Photographic Society of Great Britain. (W. Watson & Sons.)

Catalogue of Slides, Optical Lanterns, and Dissolving Views Apparatus. (E. G. Wood.)

Catalogue of Microscopes and Apparatus. (R. G. Mason.)

Catalogue of Microscopes and Apparatus. (R. & J. Beck, Ltd.)

THE INDUSTRY OF INSECTS IN RELATION TO FLOWERS.

By the Rev. Alex. S. Wilson, M.A., B.Sc.

As fertilizing agents, insects perform an indispensable service to flowers; it is only a small proportion of the available species, however, that are utilized for this work. Many blossoms depend for their fertilization exclusively on a single order of insects; others avail themselves of only a few families, and in some instances a flower's visitors appear to be confined almost entirely to a single species of insect. Besides attractions such as honey, scent, and brilliant colours, most flowers exhibit contrivances for the exclusion of undesirable guests. And it is not simply creeping and gnawing kinds, whose visits are positively injurious, that are thus excluded; many winged and harmless species are also denied access. The size and shape of an insect may even be well adapted for the fertilization of a particular flower, and yet its visits may be discouraged. Since the chances of cross-fertilization increase with the number of visitors, it is clearly of advantage for flowers to be visited by the utmost possible variety of insects; any limitation might, therefore, be regarded as prejudicial. The disadvantage of restriction may indeed be more than counterbalanced, as Herman Müller points out, if thereby the attractiveness of the flowers for special insects be increased, but the benefit arising from the limitation of insect-visits perhaps admits of fuller elucidation than it has yet received. The exclusion of certain insects from a particular flower, we have been accustomed to ascribe to the fact of their size and shape being ill-adapted for its fertilization; but there are other reasons, and it is to these that we wish to direct attention in this paper.

To appreciate the significance of the restriction, it is only necessary to compare the relative importance of the number of visitors which a flower receives with the industry of the individual visitors. If all insects of suitable size and shape visiting flowers were equally industrious, then restriction would be disadvantageous. The fundamental reason for a limited selection is to be found in the circumstance that the efficiency of any set of fertilizing agents depends not so much upon their numbers as upon the number of separate flowers which each individual visits, or, in other words, upon their industry. Ten visits made by ten different individuals are far less effectual than the same number of visits performed by a single insect. A small number of bees, butterflies, or other systematic visitors will fertilize far more flowers than a much larger number

of miscellaneous insects which only visit flowers occasionally and at random, even if the latter be equally adapted as regards bodily form. An insect in any case cannot effect cross-fertilization at all unless it visits at least two flowers. A plant will, therefore, lose rather than gain by attracting any species of which the individuals do not, during the time the plant remains in bloom, visit on an average at least two flowers apiece. The superiority of a small number of industrious insects over a larger number of indolent ones depends chiefly on the increased risk in the latter case of repeated visits being paid to the same flower. An individual bee of any intelligence will not, if it can help it, return to a flower from which it has already removed the nectar. If, however, there be a number of visitors, manifestly they cannot avoid entering many previously visited flowers, and in this way a considerable proportion of the visits are as good as lost so far as the blossoms are concerned. To illustrate the disadvantage arising from revisitation or overlapping, let us suppose that a certain area contains ten flowers; the visitation of the whole ten will be overtaken in a given time by a bee which makes ten visits in that time, assuming that the insect works intelligently so that no flower receives more than one visit. But ten miscellaneous insects, say flies, each visiting but one flower in the same period and working independently cannot, although the total number of visits is the same, overtake the whole ten flowers. Obviously there is nothing to prevent all the ten flies entering the same flower, and in that case the other nine would remain unvisited. Again, their visits might be confined to two, three, or more flowers, while the remaining ones were neglected. The ways in which the ten visits may be distributed are so numerous that it could only rarely happen that each fly went to a separate flower and the whole ten were visited. The first fly runs no risk of entering a previously visited flower; the value of its visit may, therefore, be represented as 1. The value of the second fly's visit is rather less, for although there are still nine unvisited flowers, it may chance to enter the same one as its predecessor, and the visit be lost. As there are ten flowers, the risk of this is $\frac{1}{10}$; the value of the second fly's visit is, therefore, diminished by that amount and only counts $\frac{9}{10}$. The third fly is also liable to enter the first visited flower, and there is the further contingency of its entering the same one as the second fly; the former risk, as before, is $\frac{1}{10}$; the latter $\frac{1}{10}$ of $\frac{9}{10}$, or $\frac{9}{100}$, which falls to be deducted along with $\frac{1}{10}$ from 1 to obtain the value of the third visit, which represents the average efficiency of the third fly. We have thus obtained the first terms of a decreasing geometrical series $1 \cdot + \frac{9}{10} + \frac{81}{100} + \frac{729}{1000}$, etc., the successive terms of which represent the value of each additional visitor. From the formula $s = \frac{ar^n - a}{r-1}$, where s is the sum of the series, a the first term, r the ratio, and n the number of terms, we can obtain the value of s—that is, the number of flowers overtaken by n visitors. In like manner, insects which each visit two flowers furnish a corresponding series, 2, 1·6, 1·28, etc., and similarly with those having a higher rate of industry. Arranging these results, we get the following table, in which the first vertical column shows the number of insects engaged, and the upper horizontal line their rates of industry; the other figures indicate the average number of separate flowers overtaken in each case.

From this table it will be seen that while one flower is visited in the specified time by an insect whose industry is 1, and two by an insect with twice this diligence, two insects each with unit industry can only overtake on the average 1·9. It will also be seen that ten casual visitors only overtake 6·5 out of the ten flowers in their ten visits; the difference 3·5 represents the average loss from overlapping of agency or frequenting previously visited flowers.

	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	1·9	3·6	5·1	6·4	7·5	8·4	9·1	9·6	9·9	
3	2·7	4·9	6·6	7·8	8·75	9·4	9·7	9·9		
4	3·4	5·9	7·6	8·7	9·4	9·7	9·9	9·9		
5	4·1	6·7	8·3	9·2	9·7					
6	4·7	7·4	8·8	9·5						
7	5·2	7·9	9·2	9·7						
8	5·7	8·3	9·4	9·8						
9	6·1	8·6	9·6							
10	6·5	8·9	9·7							
20	8·8									
30	9·6									
40	9·8									
50	9·9									
100	9·9									

The efficiency of five insects whose industry is 2 is slightly greater, being 6·7; the total number of visits is the same in both cases, but more are overtaken in the latter, since each insect must visit two distinct flowers. Again, when two insects are engaged, each visiting five flowers in the specified time, they overtake 7·5 out of the ten flowers in their ten visits. Lastly, if we suppose only one insect to be employed with an industry of 10, then all the flowers are overtaken, assuming that it works intelligently and visits each flower but once, for a careless or unintelligent worker will lose as much as ten different insects do by overlapping. The above figures also show that eight visitors with an industry of 2 overtake exactly the same amount as five, each having an industry of 3: there is an extra loss of one visit from overlapping in the former case. As the result of these calculations we deduce the following conclusions:—

1. The maximum effect is obtained when one insect is employed to visit the whole ten flowers.

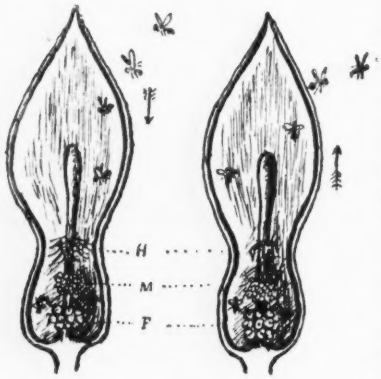
2. The industry of the individual visitors is of greater importance than their numbers.

3. When more than one insect is employed the efficiency is rapidly reduced at first, afterwards more slowly; this means that there is a premium on the higher rates of industry.

4. The effect of augmenting the industry diminishes as the number of insects employed increases; where the number of visits is greatly in excess of the number of flowers, overlapping must occur whether the excessive visitation be due to numbers or industry, and the advantage of the latter over numbers disappears. Hence industry becomes of paramount importance where insects are scarce.

It is, therefore, clear that there must be a strong tendency for the work of cross-fertilization to be left more and more to anthophilous species, to the exclusion of those insects which do not entirely restrict themselves to a floral diet. The visits of the latter are less valuable because of the inevitable amount of revisitation. If, however, the insects be very numerous in proportion to the flowers, numbers may be substituted for industry without loss of efficiency, and this consideration throws an interesting light on the peculiarities of certain blossoms. From our present point of view, entomophilous flowers may be arranged in two classes, according as they facilitate the work of their visitors or delay their operations. Where the number of insects is small relatively to the flowers, it is to the plant's advantage to expedite the work of its visitors. This is, no doubt, one reason for the presence of bright colours, scent, landing-stages, markings, or honey-guides, as well as for colour-changes such as are seen in Lantana, Hibiscus, Arnebia, and other changeable flowers, indicating to visitors, as Fritz Müller believes, those blossoms which

have already been visited. Such contrivances for saving their visitors' time benefit the flowers in the long run, since the visitors are thereby enabled to overtake a larger number of blossoms; these facilities, in fact, increase their rates of industry. There are, however, other flowers which instead of promoting the industry of their visitors imprison their guests, detaining them for a day or longer. Such is the effect of the well-known mouse-trap arrangement of hairs in Aristolochia, Ceropejia, Arum, and a few others. Flowers of this class are frequented in great numbers by minute flies or midges, which hover in clouds near the plants. On account of their numbers, little or nothing would be gained by arrangements to facilitate speedy visitation, and as little is lost by the detention of such insects. These flowers rely on the numbers of their visitors, not on their industry, and hence honey-guides and other conveniences are mostly absent. Aristolochia is protogynous, the stamens not being matured until after the stigma has been pollinated, hence the necessity for detaining the visitors until the pollen is shed; were they allowed to depart before this happened, they could confer no benefit on the next flower they entered. Further, there is in Aristolochia a special provision against revisitation, for the flower-tube becomes inverted soon after the pollen is discharged. We can hardly be in doubt, therefore, as to what were the conditions out of which this curious mouse-trap contrivance arose; the number of insects must have been greatly in excess of the flowers, and they must have belonged to the class of unsystematic or careless workers. On the other hand, the arrangements for facilitating visits, so common in flowers, could only arise with the flowers greatly in excess of the insects, and with insects of industrious habits, given to flower visitation more or less continuous. Open shallow flowers with exposed honey or pollen, being accessible to all insects, attract a great variety of visitors but the overlapping of visits must be so great that only a small proportion of the visits can be effective. Deep tubular flowers adapted to the proboscis of a bee or moth exclude short-lipped flies, and though attracting fewer visitors, yet attract a more industrious class, so that as regards cross-fertilization, the efficiency is as great or greater than in the case of shallow flowers with more numerous guests. The restriction is, therefore, advantageous, even apart from the circumstance that bees and butterflies are in respect of size and shape more desirable visitors. A difficulty is presented by very deep tubular flowers adapted exclusively to Lepidoptera, of which Lonicera, Lychnis, Gymnademia, and Habenaria are examples. *Angræcum sesquipedale*, an orchid belonging to Madagascar, with a spur ten or eleven inches long, is an extreme example of the same type. Flowers of this class exclude even bees. Now although as regards adaptation to flowers the Lepidoptera take the first place among insects, they are only of second or third rate importance as fertilizing agents. In this respect bees decidedly take the first place. They have, moreover, generally been accredited with greater diligence than butterflies. It is not easy, therefore, to see how the industry of individual visitors could be a factor in bringing about the adaptation of deep tubular flowers to the Lepidoptera. A little reflection, however, serves to show that the principle applies even here. It hardly admits of doubt that these very deep flowers are derived from ancestors which had their honey accessible to bees. Now we only need to suppose that the bees got into the way of avoiding the deepest flowers on account of the difficulty experienced in obtaining the nectar; not that fewer bees visited the deep-tubed flowers, but that each bee paid fewer visits to them. By this means not only would the total visitation of the deeper flowers be reduced and diligence in consequence gain ascendancy over numbers, but in relation to the deep flowers bees would become intermittent or casual visitors, and the value of their visits would be greatly reduced. Finding they enjoyed a monopoly of the nectar, butterflies would frequent the deep flowers with increased diligence, and their visits, from less overlapping, would become more valuable. Honey and pollen bestowed on casual visitors is for the most part wasted; and natural selection must inevitably lead to the exclusion even of bees, notwithstanding their exceptional industry, when they cease to visit any species of flower diligently.



Arum.

1.—First or female stage.—H, mouse-trap hairs; M, stamens not yet mature; F, pistils capable of fertilization.

2.—Second or male stage.—H, mouse-trap hairs withered; M, stamens discharging pollen; F, pistils fertilized in preceding stage.

The penalty of unused power is its removal; a door which a person does not often enter is likely to close against him permanently. This punishment has overtaken the bees, who now find the deep-tubed flowers their predecessors neglected closed against them for ever. This has apparently taken place in the Alps, where Müller found that many flowers, which in the lowlands are adapted to bees, have in the uplands become specialized for Lepidoptera. This result he ascribed to the scarcity of bees in the higher regions, but the scarcity of an insect can hardly account for its exclusion; rather we should expect this condition to bring about keener competition for the services of the insects, and increased attractions on the part of the flowers. The scarcity of bees cannot, therefore, be the direct cause of this change; it may, however, bring it about indirectly. As the number of bees diminishes they have a greater choice of flowers, and each honey-gatherer will naturally go to the deeper and more difficult flowers as seldom as possible. In relation to these flowers bees will thus acquire the character of casual or indolent visitors. At the same time, on account of diminished visitation, the balance is turned against numbers in favour of diligence. The butterflies meantime becoming more diligent so far as the deeper flowers are concerned, and the bees less so, we have the conditions fulfilled which lead to the exclusion of the occasional visitors, and more perfect adaptation to the habitual frequenters of the flowers. The same process in course of time would lead to still further specialization, such as is seen in Angræcum, from which the honey can only be removed by a moth having a proboscis nearly a foot in length. Butterflies and moths in some respects are, no doubt, preferable to bees as pollen-carriers; they are more purely suctorial, and do not consume such quantities of pollen as bees, neither do they use the mouth-parts for other purposes; a greater differentiation of these in relation to flowers has, therefore, been possible than in the case of bees. Müller states

generally that, among anthophilous insects, intelligence keeps pace with the length of the proboscis and other marks of special organization. At this rate we should expect butterflies to excel bees in industry and intelligence. Some of the Lepidoptera are at least as quick at their work as the bee. Mr. Darwin mentions twenty visits per minute for a bee which he timed. One of the quickest workers among the Lepidoptera is *Macroglossa stellatarum*, which was seen by H. Müller to visit one hundred and ninety-four flowers on different plants in six and three-quarter minutes—that is, at the rate of 28·7 per minute. Our contention regarding the importance of industry would be borne out, however, even although the Lepidoptera were the less industrious of the two orders. Relatively to the deeper flowers, which bees rarely visit, they are the more industrious, and this is all we are concerned to maintain in seeking to account for the exclusion of the bee from deep flowers on the score of its inferior industry.

THE HAZING EFFECTS OF ATMOSPHERIC DUST.

By Dr. J. G. McPHERSON, F.R.S.E., *Lecturer on Meteorology in the University of St. Andrews.*

THE results of Mr. John Aitken's observations during a period of eighteen months, to ascertain the hazing effect of the dust-particles in the air without the aid of the dust-counter, show that, without counting the number of dust-particles, the transparency of the atmosphere is very much destroyed by the impurities communicated to it while passing over the inhabited areas of the country. He has shown that the thickness of a haze depends on the number of dust-particles present, on the degree of saturation of the air, and to some extent also on the vapour-pressure. Supposing we had two samples of air, both at the same temperature, and both having the same depression of the wet-bulb thermometer, if one of these samples be more hazed than the other it will be found to have more dust-particles in it than the other, and to be the thicker the greater the number of particles present. And for a given number of particles, the damper the air the thicker is the haze. These conclusions placed in his hands a means of comparing the amount of dusty impurity in different masses of air, or of different airs brought to us by winds from different directions.

He took Falkirk for his centre of observations. This town lies a little to the north of a line drawn between Edinburgh and Glasgow, and is nearly midway between them. If we draw a line due west from it, and another due north, we find that in the north-west quadrant so enclosed the population of that part of Scotland is extremely thin, the country over that area being chiefly mountainous, and there is not a town in it of any size within 70 miles, with the exception of Stirling. In all the other directions the conditions are quite different. In the north-east quadrant are the fairly well-populated areas of Aberdeenshire, Forfarshire, and the thickly-populated county of Fife. In the south-east quadrant are situated Edinburgh and the well-populated districts of the south-east of Scotland. And in the south-west quadrant are Glasgow and the large manufacturing towns which surround it. Therefore, Falkirk has round it three thickly-populated areas, while the fourth is very thinly populated. The result is that while the winds from the three districts bring air polluted in its passage over populated areas, the winds from the north-west quadrant come comparatively pure. If, now, the air that comes from these several districts be compared, the effects of the products of combustion on the clearness of the atmosphere can be determined.

Mr. Aitken adopted the plan of estimating the haze by noting the most distant hill that could be seen through the haze. The distance in miles of the farthest away hill visible is then called "the limit of visibility" of the air at the time. But as it is almost never possible to get a sufficient number of hills at different distances to work in this way, he estimated the amount of haze on some hill at a known distance, and calculated from that estimate the greatest distance at which a hill could be seen under the conditions. For the observations made at Falkirk only three hills are available, one about four miles distant, the Ochils about 15 miles distant, and Ben Ledi about 25 miles distant, all in the north-west quadrant. When the air is thick, only the near hill can be seen, then the Ochils become visible as the air clears, and at last Ben Ledi is seen when the haze becomes still less. After Ben Ledi is visible, it then becomes necessary to estimate the amount of haze on it, in order to get the limit of visibility of the air at the time. Thus, if Ben Ledi be half-hazed, then the limit of visibility will be 50 miles. In this way all the estimates of haze have been reduced to one scale for comparison.

After going over the hundreds of observations made in his note-book during these eighteen consecutive months, and rejecting all those which were unsatisfactory, from the conditions being uncertain, there remained two hundred observations, which he has classified and arranged for the determination of the hazing effects of atmospheric dust. As the density of the haze could only be compared on those days when the humidity was the same, the first thing was to arrange all the observations in tables according to the wet-bulb depression at the time. Tables were accordingly prepared, in one of which the observations made when the wet-bulb depression was 2° were entered; and so on for depressions of 3° up to 8°. The different observations in each table were at the same time entered in such a manner that all those made when the wind was north were put together, all those when it was north-east next each other, and so on.

I will now give an abstract of these tables. As the dryness of the air increases, the limit of visibility also increases. When the wet-bulb depression was 2°, the east wind had a limit of 10 miles, and increased to 22 miles when the air was dry enough to give a wet-bulb depression of 8°. The south wind increased from 8 to 32 miles, the west from 7 to 17 miles, and the north from 50 to 172 miles. There is a very great difference in the transparency of the wind from the different directions. In the north-west quadrant the winds made the air very clear, whereas winds from all other directions made the air very much hazed. The winds in the other three areas are nearly ten times more hazed than those from the north-west quadrant. When the wet-bulb depression is 2°, the wind from that quadrant is about 6·2 times clearer than air coming from the best of the other areas; and when the air is drier than gives more than 2° depression, the mean of all the observations shows that the air from the north-west quadrant is more than nine times clearer than that from the other directions. That is, the table shows that the air from densely-inhabited districts is so polluted that it is fully nine times more hazed than the air that comes from the thinly-inhabited districts; in other words, the atmosphere at Falkirk is about ten times thicker when the wind is east or south than it would be if there were no fires and no inhabitants.

It may be interesting to show how much the individual observations differed from each other. The limit varies

considerably for the same wind at the same humidity. That is what might have been expected, because from the observations made by the dust-counter, the number of particles varied greatly in winds from the same directions, but at different times. This depends upon the rise and fall of wind, changes in the state of trade, season of the year, and other causes. During the last strike the dearth of coal would make a considerable diminution in the number of dust-particles in the air of large towns. With a north wind, the extreme limits of visibility are 120 to 200 miles; and a north-west wind from 70 to 250 miles. An east wind had as limits 4 to 50 miles, and a south-west wind 2 to 60 miles.

One interesting fact to be noticed is this: that as a general result, the transparency of the air increases about 3·7 times for any increase in dryness from 2° to 8° of wet-bulb depression. That is, the clearness of the air is inversely proportional to the relative humidity, or, put another way, if the air is four times drier, it is about four times clearer. It may be thought by some that the highest limit of visibility given in the tables is too great; that 250 miles is too great a distance for a mountain to be visible—that is, supposing it was above the horizon. This estimate has been made, as above explained, by determining the amount of haze on Ben Lomond, 25 miles distant from the place of observation, and as this mountain was occasionally estimated to be only one-tenth hazed, that gives 250 miles as the limit on these occasions. But in previous observations on the Rigi Kulm, in Switzerland, Mr. Aitken had often seen Hochgorrach so clearly that it did not look more than a quarter hazed. Now, as that mountain is 70 miles distant from the Rigi, it makes the limit of visibility on these occasions about 300 miles.

THE WEB OF THE GARDEN SPIDER.

By E. A. Butler, B.A., B.Sc.

THE accompanying photograph represents the geometric web of the common garden spider, *Epeïra diadema*. The spider itself appears in the centre of the web, in its usual position, head downwards, and with its under surface towards the observer. It is engaged in manipulating some insect which has just flown into the snare and considerably damaged it, especially on the right-hand side. The insect has been completely disabled by a strong silken covering which has been wrapped round its body so as to enswathe it like a mummy. In order to do this the spider seized its prey, fastened threads to its body, and then rapidly twirled it round by skilful movements with its feet, a band of silk being at the same time drawn out from the spinnerets and wound round the body. This species of spider may easily be recognized by its yellowish or brownish body, which is adorned on the summit of the abdomen with some pure white markings, the most conspicuous of which are in the form of a cross. From this cross is derived the name "porte-croix," by which the spider is known in France.

No better example of the geometric web could be found than that of the garden spider, and it is so familiar an object, through its large size, and the abundance of the species that constructs it, that one is apt to associate, though wrongfully, this particular kind of web with spiders in general. There are many kinds of spiders that do not construct a snare at all, but hunt their prey and leap upon it. And of those that do construct a snare, it is only one family that adopts the geometric pattern. Still, as this family, the *Epeïridæ*, contains some of the largest, as well as one of the commonest species, the geometric style is the one usually thought of when spiders' webs are mentioned. The geometric web of *Epeïra diadema* is spread perpendicularly over an irregularly polygonal area, the exact form of which is dependent upon the herbage and other objects amongst which it is placed. In addition to the strong threads that form its boundary, not shown in the photograph, it consists of a number of straight lines radiating from the centre to the circumference, and a series of lines crossing these. These latter do not form

Web of the Common Garden Spider.

what their first appearance no doubt suggests, a series of concentric circles, or rather polygons, but they are constituted by a single thread wound round and round in a spiral fashion. This first proceeds from the centre to the circumference in such a way that the distances between the successive turns is double what it will ultimately be, and then the coil is carried backwards from circumference to centre, half-way between the previously formed convolutions.

There is a considerable difference between the radii and the cross lines. The former are stronger, less elastic, and much less sticky than the latter, and are composed of a compound strand proceeding from more or fewer of the spinning tubes which open on the spinnerets. The cross lines are somewhat finer, and, when freshly formed, have a number of globules of viscid silk all along them, like glittering beads on a string. This beaded appearance can be traced, with the help of a lens, in one of the threads in the right-hand top corner of the photograph, but it can hardly be seen elsewhere, as the web was not a freshly-formed one, and these globules of viscid matter dwindle on exposure to the sun, apparently by evaporation, whence the necessity for frequent repair, and possibly even the construction of a new web. Since these beaded threads do not harden on exposure to the air as the radii do, it is they chiefly that are the agents of detention when an insect flies into the snare.

The method of construction of such a web is interesting, and we will follow it in detail. The outline enclosing the area to be filled is first formed, and for this purpose the wind is made to lend some aid. The spider sits upon a leaf or other support, exposing its spinnerets to the wind, and by this means a thread is gradually drawn out and floats behind the creature till the free end comes in contact with some object, to which it at once adheres. Others will be formed and fixed in the same way, or by the spider dropping from point to point and carrying its thread with it. This goes on till an irregular area is enclosed. The radii are the next parts to be made. Proceeding to the centre of the upper boundary, the spider attaches a thread to it and then drops down to the opposite one, where the thread is again fastened, and thus we have the first diameter. This thread can now be used as a climbing pole, and the spider swarms up it, and attaching a new thread at its middle point, climbs up the rest of the distance, drawing out the thread as it goes. On reaching the horizontal boundary it turns aside and travels a short distance along it, thus stretching the newly-made thread across in a sloping direction from the first point of attachment to the point it has now reached, where a new attachment is made. Returning to the centre, the spider carries another line up in the same way, fastening its free end a little further on, and so on till all the radii have been laid down.

The next business is to put in the spiral thread. This, as already mentioned, is of different texture from the radii, and commences at the centre. Fastening the beginning of its new and more viscid thread at the centre, the spider crawls from radius to radius, going round and round in a spiral direction, and as it crosses each radius it fastens there the thread that trails behind it, using its hind legs to assist in the process. Having reached the outermost limit of its web, it retraces its steps, but threads the maze backwards between the lines already laid down, fastening each strand as it advances, just as it did on the way out, till it reaches the centre. Thus the cross lines of the web are in the form of a double spiral, the coils of the return half lying alternately with the rest. As a snare, the web is now practically complete; but the spider will not unfrequently improve its elasticity and powers of resistance by biting out a small part in the centre, thus severing the connection of the radii with one another, and throwing the burden of resistance upon the cross strands. If any object now gets entangled in the web, the highly elastic cross strands yield to its struggles, carrying the stiffer but now disconnected radii with them, and thus there is less likelihood of the main threads snapping, a catastrophe which might be followed by the escape of the prey. Any entanglement of cross threads that may take place can soon be set right again, and the damage, so far from being a drawback, may actually be advantageous, as it will lead to the substitution of new and more viscid threads for the older ones that have lost a good deal of their original viscosity.

A newly-formed web will usually be found to be very regular, but as time advances irregularities soon begin to appear, through the interference of wind and weather, as well as of insects flying into it. One of the commonest irregularities is that which is exhibited in many parts of the web represented in the photograph; two consecutive threads of the spiral have coalesced to form a single one for the greater part of their length, separating from one another only near the ends when they slope off to their respective attachments to the radii. This evidences both their elasticity and viscosity, for being stretched they have met, and then have adhered together.

The web, as just described, is intended to serve as a snare for the capture of prey, and not as a place of abode, even though the spider may often be seen at its centre where the web is not viscid. The spiders of the family *Epeiridæ* usually construct a cell or nest in some concealed spot near the web, and this is the true place of abode. It is connected with the snare by a strong line running to the centre of the latter, which forms a kind of tight-rope along which the spider passes when the sudden appearance of a desirable victim in the snare demands its immediate attention. If the insect is not too large, it will be at once twirled round and enswathed in silk, whereby its struggles will be prevented, and yet it will be kept alive and fresh, so that its captor can at any time obtain for itself a supply of fresh provisions.

THE FACE OF THE SKY FOR DECEMBER.

By HERBERT SADLER, F.R.A.S.

BOTH spots and faculæ are still very numerous on the Sun's disc. Conveniently observable minima of Algol occur at 7h. 32m. P.M. on the 3rd, 4h. 20m. P.M. on the 6th, 9h. 13m. P.M. on the 23rd, and 6h. 2m. P.M. on the 26th.

Mercury is a morning star, and but for his southern declination would be well situated for observation during the first half of the month. He rises on the 1st at 5h. 50m. A.M., or 1h. 56m. before the Sun, with a southern declination of 16° 6′, and an apparent diameter of 6·0″, $\frac{73}{100}$ths of the disc being illuminated. On the 9th he rises at 6h. 20m. A.M., or 1h. 36m. before the Sun, with a southern declination of 19° 34′, and an apparent diameter of 5$\frac{1}{4}$″, $\frac{85}{100}$ths of the disc being illuminated. On the 14th he rises at 6h. 45m. A.M., or 1h. 15m. before the Sun, with a southern declination of 21° 28′, and an apparent diameter of 5·0″, $\frac{9}{10}$ths of the disc being illuminated. On the 19th he rises at 7h. 7m. A.M., or about one hour before the Sun, with a southern declination of 23° 0′, and an apparent diameter of 4$\frac{3}{4}$″, $\frac{95}{100}$ths of the disc being illuminated. After this he is too near the Sun to be easily observed. While visible he pursues a direct path through

portions of Libra and Scorpio into Ophiuchus, being 3′ south of the 2nd magnitude star β^1 Scorpii at 5h. A.M. on the 10th.

Venus is too near the Sun for observation in December.

Mars is an evening star, and can still be observed, though his apparent diameter is getting perceptibly smaller. He rises on the 1st at about 1h. 50m. P.M., with a northern declination of 8° 47′, and an apparent diameter of 15·0″, the phase on the *n f* limb amounting to nearly 1″. On the 10th he rises at 1h. 15m. P.M., with a northern declination of 9° 41′, and an apparent diameter of 13½″, the phase amounting to 1·1″, and the apparent brightness of the planet being about what it was in the middle of August. On the 17th he rises at 0h. 50m. P.M., with a northern declination of 10° 32′, and an apparent diameter of 12½″, the phase amounting to 1·1″. On the 24th he rises at 0h. 25m. P.M., with a northern declination of 11° 29′, and an apparent diameter of 11½″. On the 31st he rises at noon, with a northern declination of 12° 31′, and an apparent diameter of 10¾″, the phase amounting to 1·1″, and the apparent brightness of the planet being about the same as it was about the end of June. Mars describes a direct path from the confines of Pisces into Aries.

Jupiter is an evening star, and is very well situated for observation, being in opposition on the 23rd (distance from the earth about 386 millions of miles). He rises on the 1st at 5h. 21m. P.M., with a northern declination of 23° 7′, and an apparent equatorial diameter of 46″. On the 6th he rises at 4h. 58m. P.M., with a northern declination of 23° 9′, and an apparent equatorial diameter of 46½″. On the 16th he rises at 4h. 13m. P.M., with a northern declination of 23° 12′, and an apparent equatorial diameter of 46·8″. On the 24th he rises at 3h. 34m. P.M., with a northern declination of 23° 14′, and an apparent equatorial diameter of 46·8″. On the 31st he rises at 3h. 3m. P.M., with a northern declination of 23° 15′, and an apparent equatorial diameter of 46·7″. During the month the planet pursues a retrograde path in Gemini, to the west of μ Geminorum. The following phenomena of the satellites occur while the Sun is 8° below and Jupiter 8° above the horizon:—On the 1st a transit ingress of the shadow of the second satellite at 8h. 53m. P.M., of the satellite itself at 9h. 57m. P.M., a transit egress of the shadow of the satellite at 11h. 29m. P.M. At midnight an 8½ magnitude star will be between the third satellite and the planet. On the 2nd a transit egress of the second satellite at 0h. 33m. A.M., a transit ingress of the shadow of the first satellite at 6h. 40m. A.M.; an eclipse disappearance of the third satellite at 9h. 5m. 24s. P.M.; a central occultation of a 10th magnitude star at 7h. A.M. On the 3rd an occultation reappearance of the third satellite at 1h. 51m. A.M., an eclipse disappearance of the first satellite at 3h. 50m. 5s. A.M.; an occultation reappearance of the first satellite at 6h. 34m. A.M.; an occultation reappearance of the second satellite at 7h. 36m. P.M. On the 4th a transit ingress of the shadow of the first satellite at 1h. 8m. A.M., of the satellite itself at 1h. 37m. A.M.; a transit egress of the shadow of the first satellite at 3h. 24m. A.M., and of the satellite itself at 3h. 53m. A.M.; an eclipse disappearance of the first satellite at 10h. 18m. 36s. P.M. On the 5th an occultation reappearance of the first satellite at 1h. 0m. A.M., a transit ingress of its shadow at 7h. 37m. P.M., a transit ingress of the satellite itself at 8h. 3m. P.M., a transit egress of the shadow at 9h. 53m. P.M., and of the satellite itself at 10h. 19m. P.M. On the 6th an occultation reappearance of the first satellite at 7h. 26m. P.M. On the 7th an eclipse disappearance of the second satellite at 5h. 20m. 49s. A.M. On the 8th a transit ingress of the shadow of the second satellite at 11h. 29m. P.M. On the 9th a transit ingress of the second satellite at 0h. 12m. A.M., a transit egress of its shadow at 2h. 5m. A.M., and a transit egress of the satellite itself at 2h. 48m. A.M. On the 10th an eclipse disappearance of the third satellite at 1h. 5m. 13s. A.M., its occultation reappearance at 5h. 9m. A.M.; an eclipse disappearance of the first satellite at 5h. 44m. 21s. A.M.; an eclipse disappearance of the second satellite at 6h. 38m. 16s. P.M., and its occultation reappearance at 9h. 50m. P.M. On the 11th a transit ingress of the shadow of the first satellite at 3h. 3m. A.M., a transit ingress of the satellite itself at 3h. 21m. A.M., a transit egress of its shadow at 5h. 19m. A.M., and of the satellite itself at 5h. 37m. A.M. On the 12th an eclipse disappearance of the first satellite at 0h. 12m. 53s. A.M., its occultation reappearance at 2h. 44m. A.M., a transit ingress of its shadow at 9h. 31m. P.M., a transit ingress of the satellite itself at 9h. 47m. P.M., a transit egress of the shadow at 11h. 47m. P.M., and a transit egress of the satellite itself three minutes after midnight. On the 13th a transit egress of the shadow of the third satellite at 6h. 1m. P.M., an eclipse disappearance of the first satellite at 6h. 41m. 33s. P.M., a transit egress of the third satellite at 6h. 59m. P.M., and an occultation reappearance of the first satellite at 9h. 10m. P.M. On the 14th a transit egress of the shadow of the first satellite at 6h. 16m. P.M., and a transit egress of the satellite itself at 6h. 29m. P.M.; a transit ingress of the shadow of the second satellite at 2h. 5m. A.M., a transit ingress of the satellite itself at 2h. 26m. A.M., a transit egress of the shadow at 4h. 42m. A.M., and a transit egress of the satellite itself at 5h. 3m. A.M. On the 17th an eclipse disappearance of the third satellite at 5h. 4m. 34s. A.M.; an eclipse disappearance of the second satellite at 9h. 13m. 20s. P.M. On the 18th an occultation reappearance of the second satellite at 0h. 3m. A.M.; a transit ingress of the shadow of the first satellite at 4h. 57m. A.M., and a transit ingress of the satellite itself at 5h. 4m. A.M. On the 19th an eclipse disappearance of the first satellite at 2h. 7m. 20s. A.M., and its occultation reappearance at 4h. 28m. A.M.; a transit egress of the shadow of the second satellite at 6h. 0m. P.M., and a transit egress of the satellite itself at 6h. 10m. P.M.; a transit ingress of the shadow of the first satellite at 11h. 25m. P.M., and a transit ingress of the satellite itself at 11h. 30m. P.M. On the 20th a transit egress of the shadow of the first satellite at 1h. 42m. A.M., and a transit egress of the satellite itself at 1h. 46m. A.M.; a transit ingress of the shadow of the third satellite at 7h. 11m. P.M., a transit ingress of the satellite itself at 7h. 26m. P.M.; an eclipse disappearance of the first satellite at 8h. 36m. 2s. P.M.; a transit egress of the shadow of the third satellite at 10h. 1m. P.M., a transit egress of the satellite itself at 10h. 14m. P.M.; an occultation reappearance of the first satellite at 10h. 53m. P.M. On the 21st a transit ingress of the shadow of the first satellite at 5h. 54m. P.M., a transit ingress of the satellite itself at 5h. 56m. P.M. (here the satellite will possibly occult its shadow), a transit egress of the shadow at 8h. 10m. P.M., and of the satellite itself at 8h. 12m. P.M. On the 22nd an occultation reappearance of the first satellite at 5h. 19m. P.M.; at 10h. 20m. P.M. a 7⅓ magnitude star is 18″ north of the limb. On the 23rd a transit ingress of the shadow of the second satellite at 4h. 41m. A.M., and of the satellite itself at the same time (the satellite probably occulting its shadow). On the 24th an occultation disappearance of the second satellite at 11h. 40m. P.M. On the 25th an eclipse reappearance of the second satellite at 2h. 20m. 15s. A.M.; a transit ingress of the first satellite at 6h. 48m. A.M., and a transit ingress of its shadow at 6h. 51m. A.M. On the

26th an occultation disappearance of the first satellite at 3h. 55m. A.M., and its eclipse reappearance at 6h. 13m. 57s. A.M.; a transit ingress of the second satellite at 5h. 49m. P.M., of its shadow at 6h. 0m. P.M.; a transit egress of the satellite itself at 8h. 25m. P.M., and a transit egress of the shadow of the satellite at 8h. 37m. P.M. At 6h. P.M. the $5\frac{3}{4}$ magnitude star 3 Geminorum will be $1\frac{1}{4}'$ f and 6·0′ north. On the 27th a transit ingress of the first satellite at 1h. 20m. A.M., a transit ingress of its shadow at 1h. 20m. A.M.; a transit egress of the satellite at 3h. 30m. A.M., and a transit egress of its shadow at 3h. 36m. A.M.; an occultation disappearance of the first satellite at 10h. 21m. P.M.; a transit ingress of the third satellite at 10h. 41m. P.M.; a transit ingress of its shadow at 11h. 11m. P.M. At 8 p.m. a 10th magnitude star will be $\frac{3}{4}'$ south of the limb. On the 28th an eclipse reappearance of the first satellite at 0h. 42m. 43s. A.M.; a transit egress of the third satellite at 1h. 29m. A.M., and a transit egress of its shadow at 2h. 2m. A.M.; a transit ingress of the first satellite at 7h. 39m. P.M., a transit ingress of its shadow at 7h. 48m. P.M.; a transit egress of the satellite at 9h. 55m. P.M., and of its shadow at 10h. 5m. P.M. On the 29th an eclipse reappearance of the first satellite at 7h. 11m. 24s. P.M. The fourth satellite will be in superior geocentric conjunction at 3h. 33m. A.M. on the 15th, and at 5h. 34m. P.M. on the 31st; at inferior geocentric conjunction at 8h. 50m. P.M. on the 6th, and at 10h. 55m. A.M. on the 23rd; and in superior heliocentric conjunction at 1h. 34m. A.M. on the 14th, and 7h. 43m. P.M. on the 31st.

Saturn and Uranus are, for the observer's purposes, invisible.

Neptune is an evening star, and is excellently situated for observation, being in opposition to the Sun on the 6th, at a distance from the earth of about $2681\frac{1}{2}$ millions of miles. He rises on the 1st at 4h. 15m. P.M., with a northern declination of 21° 2′, and an apparent diameter of 2·7″. On the 31st he rises at 2h. 10m. P.M., with a northern declination of 20° 57′. A map of the small stars near his path will be found in the *English Mechanic* for September 7th, 1894. He describes a retrograde path to the S.W. of ϵ Tauri.

December is a fairly favourable month for shooting stars, the chief showers being those of the Geminids on December 9th to 12th, the radiant point being in R.A. 7h. 0m., and north declination 32°, rising about 4h. 10h. P.M., and setting at 1h. 40m. A.M.; and of the Andromedas, occurring on the evenings of the 26th and 27th, the radiant point being in R.A. 1h. 40m., and north declination 43°, the shower being circumpolar.

The Moon enters her first quarter at 0h. 15m. P.M. on the 5th; is full at 7h. 46m. P.M. on the 12th; enters her last quarter at 11h. 16m. A.M. on the 19th; and is new at 2h. 20m. A.M. on the 27th. She is in apogee at 7h. P.M. on the 2nd (distance from the earth 251,720 miles); at perigee at 3h. P.M. on the 14th (distance from the earth 224,670 miles); and in apogee again at midday on the 30th (distance from the earth 252,330 miles). At 9h. 8m. P.M. on the 8th the 6th magnitude star π Piscium will disappear at an angle of 55°, and reappear at 10h. 23m. P.M. at an angle of 238°. At 10h. 50m. P.M. on the 9th the 6th magnitude star 27 Arietis will disappear at an angle of 136°, and reappear at 11h. 13m. P.M. at an angle of 172°. At 11h. 17m. P.M. the $6\frac{1}{2}$ magnitude star 66 Arietis will disappear at an angle of 70°, and reappear at 0h. 29m. on the 11th at an angle of 251°. At 3h. 27m. A.M. on the 11th the 6th magnitude star 9 Tauri will disappear at an angle of 95°, and reappear at 4h. 22m. A.M. at an angle of 244°; and at 7h. 24m. P.M. the $5\frac{1}{2}$ magnitude star χ^1 Tauri will disappear at an angle of 88°, and reappear at 8h. 25m. P.M. at an angle of 232°. At 11h. 14m. P.M. on the 12th the $6\frac{1}{2}$ magnitude star B.A.C. 1746 will disappear at an angle of 152°, and reappear at 11h. 42m. P.M. at an angle of 196°. At 6h. 30m. A.M. on the 13th the 5th magnitude star 136 Tauri will disappear at an angle of 118°, and reappear at 7h. 18m. A.M. at an angle of 253°. At 7h. 3m. P.M. on the 15th the $4\frac{1}{2}$ magnitude star γ Cancri will be occulted at an angle of 120°, and will reappear at 7h. 50m. P.M. at an angle of 263°. At 10h. 47m. P.M. on the 18th the 6th magnitude star 89 Leonis will disappear at an angle of 63° (the star being below the horizon of Greenwich), and will reappear at 11h. 19m. P.M. at an angle of 251° (the star rising at the time). At 1h. 37m. A.M. on the 20th the 6th magnitude star B.A.C. 4200 will disappear at an angle of 159°, and reappear at 2h. 25m. A.M. at an angle of 265°. At 3h. 33m. A.M. the $6\frac{1}{2}$ magnitude star B.A.C. 4225 will disappear at an angle of 124°, and reappear at 4h. 42m. A.M. at an angle of 310°; at 7h. 4m. A.M. the 6th magnitude star f Virginis will disappear at an angle of 84°, and reappear at 7h. 57m. A.M. at an angle of 350°. At 7h. 9m. A.M. on the 20th the 3rd magnitude star π Scorpii will disappear at an angle of 150°, and reappear at 8h. 9m. A.M. at an angle of 258°. At 5h. 46m. P.M. on the 31st the 6th magnitude star 45 Aquarii will disappear at an angle of 55°, and reappear at 6h. 57m. P.M. at an angle of 235°. The following are near approaches. On the 4th the $6\frac{1}{2}$ magnitude star B.A.C. 7835 at an angle of 148°. At 4h. 30m. P.M. on the 10th the $4\frac{1}{2}$ magnitude star ζ Arietis at an angle of 155° ($2\frac{1}{2}'$ from the limb). At 8h. 40m. A.M. (in broad daylight) on the 22nd the 6th magnitude star B.A.C. 4722 at an angle of 212°.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of November Problems.

No. 1.—By Mrs. W. J. Baird.

Key-move.—1. Kt to KB7.

If 1. . . . K to R3, 2. Q to R8ch.
1. . . . K to B3, 2. Q to B8ch.
1. . . . Any other, 2. Kt to Q6ch.

CORRECT SOLUTIONS received from J. T. Blakemore, White Knight, A. Louis, W. Willby, J. St. L. Kirwan, F. H. Bolton, E. W. Brook.

No. 2.—By C. D. Locock.

1. R to Kt4, and mates next move.

CORRECT SOLUTIONS received from J. E. Gore, J. T. Blakemore, Norman Alliston, White Knight, H. S. Brandreth, A. Louis, W. Willby, E. W. Brook, J. St. L. Kirwan, J. McRobert.

We note with pleasure some new additions to our list of solvers.

H. S. Brandreth.—And if the Pawn does not queen?

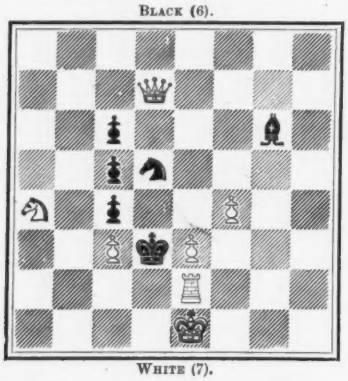
J. E. Gore.—Your two-mover No. 1 has now many solutions, *e.g.*, 1. Q × KP or 1. Kt moves anywhere discovering check. This should be corrected without increasing the force. No. 2 is clearly solved by B to R6ch or Q × R. There are also numerous duals.

XUM

PROBLEMS.

By A. C. CHALLENGER.

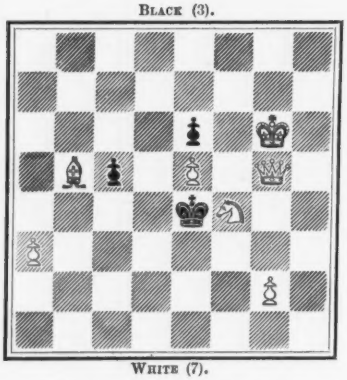
BLACK (6).



WHITE (7).

White mates in two moves.

BLACK (3).



WHITE (7).

White mates in three moves.

CHESS INTELLIGENCE.

Mr. Lasker has now nearly recovered from an attack of typhoid fever, which has prevented him from keeping various chess engagements. During his illness his brother, Dr. Lasker of Berlin, has been in London.

An interesting tournament is in progress at New York. Messrs. Steinitz, Pillsbury, Showalter, Albin, and Jasnagrodsky are among the competitors. Mr. Steinitz holds the lead, and should have no difficulty in keeping it.

A match between the Metropolitan and City of London Chess Clubs was played last month. There were fifty players on each side. The final score was: Metropolitan, 26½, City of London, 23½.

Sussex and Hants played their match in the Southern Counties Tournament at Portsmouth on November 3rd, resulting in a victory for Sussex. The important match between Surrey and Sussex takes place at Brighton on December 8th.

PAWNS AND THEIR WEAKNESSES.

(*Continued from page* 264.)

The two kinds of weak Pawns discussed in the last number were (1) isolated Pawns and (2) Pawns too far advanced. We offer here a few remarks on three other classes.

III. *Pairs of Pawns.*—It frequently happens in the close game that both sides have Pawns at K3, Q4, and QB4, while one side (say Black) has also a Pawn at QKt3. If White now play BP×P, KP×P; P×P, P×P, Black is left with a pair of Pawns at Q4 and QB4. These, as they stand, may be fairly strong, though White has open files in front of both. Nevertheless, such a pair of Pawns must be considered a permanent disadvantage, for the following reasons:—(1) If one is exchanged, the other is left isolated. (2) If one is advanced, a "hole" is left in front of the other, and this hole can be permanently occupied by a White piece, strongly placed in the centre of the board.

IV. *A Pawn supporting two others.*—Here there is clearly a "hole" in front of the supporting Pawn. This "hole" may be either temporary or permanent; if the opponent has Pawns immediately in front of the two supported Pawns, the weakness has every appearance of permanency. The category may even be enlarged. Generally speaking, it may be stated that every Pawn (unprotected by another Pawn) which cannot advance to the *same row* as its neighbours is weak. For instance, a player has a Pawn at QB4, a Pawn at QKt2 or 3, his QRP being either off the board or at QR4; the opponent has a Pawn at either QR4 or QB4. The result is that the Pawn at QKt2 or 3 is weak. If the opponent has not Pawns at both QB4 and QR4, the weakness may be only temporary, for the KtP may be advanced by the support of pieces. If, however, the opponent *has* Pawns at QB4 and QR4, the weakness is clearly permanent.

V. *Doubled Pawns.*—The weakness of these has already been treated of in an article entitled *More Chess Fallacies*. It need only be stated here that the weakness makes itself felt chiefly in the end game. In the middle game a doubled Pawn is frequently a very tangible advantage, especially if it can be *undoubled* at will.

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